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CONTRIBUTIONS IN THE FIELDS OF NEUROLOGY, NEUROSURGERY, GENERAL SURGERY AND ALLIED SUBJECTS

BY HIS FORMER STUDENTS
AND ASSOCIATES IN HONOR OF

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1934 Elected Trustee of the University of Pennsylvania

AN APPRECIATION

Born in Philadelphia in 1870, graduated from the College Department of the University of Pennsylvania in 1889 and from its Medical School in 1892, Doctor Frazier's whole career has been centred in his native city and, with the exception of a part of his early medical training in Berlin, his professional activities have been confined to the University of Pennsylvania.

After an early probationary period of service in subordinate positions in surgery at the University, Episcopal, and Philadelphia General Hospitals extending from 1896 to 1901, he was elected Professor of Clinical Surgery in the latter year and thereafter devoted himself to general surgery during the next fifteen years. Subsequently and to the present time his almost exclusive interest has been in the domain of neurosurgery—a field which owes to him some of its brilliant achievements.

During the forty-year period of his service as a teacher, hundreds of hospital interns and younger surgeons and thousands of medical students have profited by his teaching and his example and many of his colleagues in other fields of medical work have received from him collaboration in their problems that has been of inestimable value. This volume is a tribute of these pupils and colleagues who through many years have worked under him and with him and who wish in this enduring form to record their affectionate regard and their professional esteem.

Before any reference is made to the major interest of his life-work, that of neurosurgery, it is appropriate to state that his activities—medical and otherwise—have reached out in various directions and that he has had keen interests quite apart from his scientific vocation.

During a period of ten years, in addition to his duties as Professor of Clinical Surgery, he was Dean of the Medical School and served in that office with conspicuous ability. This was during a transitional period in American medical education when newer methods and reorganization of objective were considerations of major importance and his efforts during this time were of the greatest value to the Medical School.

As a means to an end he established and, during the years of his Deanship, edited the University of Pennsylvania Medical Magazine which served as an exemplification of the scientific efforts and aspirations of the Medical School and accomplished the useful purpose of coördinating such activities within the School and carrying the message to the profession outside.

In 1910 his interest in the betterment of medical practice in hospitals and outside led him to associate with others in establishing in the University Hospital a Social Service Department, the second, perhaps, in this country, and his interest in it and in its growth and development has continued to this day. Whatever it has achieved is more largely due to his unremitting interest than to any other factor.

In 1914 he organized the Public Charities Association of Pennsylvania of which he has been President since its foundation and has built up a state-wide group that has exercised a most salutary influence on the State's care of handicapped, feeble-minded, insane and penal classes. No matter how intensely he might be occupied with his immediate professional labors, he never lacked time to devote himself whole-heartedly to this important public work.

This background of record of a full life of service as a medical teacher, a practicing surgeon, a University officer, and a citizen devoted to the public good serves to give added emphasis to the significance of his achievement in the field of his heart's desire, the technical branch of surgical science which attracted him and has held his devotion through the last twenty years. Many who have attained fame and distinction in lines of applied scientific endeavor have done so with the quite apparent object of success in a practical sense. Their achievements, however brilliant, lack the fine impersonal distinction that essentially characterizes the work of the pure scientist who strives to establish new facts

and has no object beyond this—whether his facts be immediately profitable or otherwise. Those who have been close to Doctor Frazier in his work cannot but appreciate that his intensive devotion to every technical aspect of it has been unselfishly directed toward establishing new views and methods and to the development of neurosurgery.

From about 1918 to the present day his entire surgical interest and life has been devoted to the cultivation of neurosurgery and he has been, in this country as well as throughout the world, one of the band of pioneers who have established this fruitful branch of surgery as a new field of medical science. His conception of its domain has not been that of a surgeon prepared to lend his skill to the neurologist who has indicated what may be done, but rather that of the neurosurgeon who combines neurological conceptions with surgical solutions. The field of neurosurgery has not yet been accurately defined. It assuredly is not that of a surgeon who merely performs the operations requested by a neurologist; it is with equal certainty not that of a neurologist who cultivates a modicum of skill as an operator; still less is it the domain of the surgeon who arrogates to himself the whole field of neurology, operating where it seems proper and leaving the rest to others or to fate. Neurology is a wide field merging into clinical medicine on one side, into psychiatry on another, into the newer field of endocrinology and the science of nutrition on yet another, and having its most practical possibilities of relief in neurosurgery.

The developments of Frazier's work have exemplified a recognition of these distinctions. From the beginning of his neurosurgical activities his close association with his distinguished colleague, Spiller, established a combination of neurology and surgery of unique character. Together they laid the foundations for new and fruitful neurosurgical procedures and Frazier's zeal in perfecting methods and technic has expanded the scope of his work and that of his pupils far beyond the earlier conceptions of neurosurgery.

It would be idle for one, not technically informed, to attempt an evaluation of the relative merits of the many types of operation and innovation that stand to his credit, but among them it is clear to all that the introduction of a new and simplified procedure for the surgical cure of tic douloureux and his performance of this operation in over 700 cases is an outstanding achievement; that his contributions to the technic and his experience with the operation "chordotomy" led to its recognition by the medical profession; that his extensive experience with pituitary diseases and his introduction of new methods of surgical approach have made him a master in this field; and that his other work in brain tumors, nerve anastomosis and a variety of other neurosurgical procedures have rounded out a career of extraordinary productiveness.

It should not remain unnoted that during the World War Frazier was consultant in neurosurgery to the Surgeon General of the Army and conducted a large Government Hospital for the care of neurosurgical patients sent back from France. Many distinguished neurologists and neurosurgeons here came under his direction and teaching and some of his results, such as the report on 200 cases of gunshot wound of the head, on 500 cases of injuries of peripheral nerves, and on their reconstruction indicate the extent of this experience. It is perhaps of some interest to note that Philadelphia's first neurosurgeon, W. W. Keen, laid the foundations for his later career during our Civil War in a similar position, and, like Frazier, he was in his earlier work closely allied with a neurological colleague—S. Weir Mitchell.

As the horizon of his interest has widened, newer directions of research and practical exploration have attracted him and in all that he has done his associates and colleagues have noted with admiration the painstaking accuracy with which he has planned and performed every step however small or large.

Little wonder therefore that those who have enjoyed the privilege of association with him have joined so enthusiastically in the production of a *Festschrift* to do him honor!

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Part One

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PHYSIOLOGICAL ASPECTS OF DISEASES OF THE OPTIC NERVE

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The reactions of the optic nerve to injury and disease differ in many respects from those of other sensory nerves, and these differences peculiar to the optic nerve can be partly explained by a general understanding of the anatomy and physiology of this nerve. It is the purpose of this paper to point out some of these relationships, and to show how they may help us understand the signs and symptoms of certain lesions commonly encountered.

The optic nerve fibres are derived from the retina. When the embryo is about four millimetres long, the optic stalk is an open tube connecting the optic vesicle to the fore-brain. At about this stage the ganglion cells begin to send their processes into this open tube, and as these grow they ascend into the brain where they eventually connect with the cells which form the external geniculate body.

The nerve fibres are really a part of a tract of the central nervous system, since the retina has developed from the optic vesicle which is an outpouching of the original neural tube. They do not have the same origin, therefore, as the fibres of ordinary sensory nerves, which grow into the cerebrospinal axis from structures outside the primitive neural tube.

The essential part of every nerve fibre in the body is a delicate thread-like axon. The most obvious difference between different kinds of fibres depends upon the nature of the covering of the axon. Most axons are covered with a thick, fatty sheath of myelin and hence are called myelinated. When this sheath is absent the fibre is said to be unmyelinated. Outside this myelin sheath nearly all sensory nerves have a second sheath, thin, delicate

and membranous, termed the primitive sheath or neurilemma. This latter sheath is important from the standpoint of regeneration of nerve fibres, as will be pointed out later.

The optic nerve fibres are composed of the usual axon and the myelin sheath but lack entirely the primitive or neurilemmal sheath. The fibres are not separated from one another by neurilemmal sheaths as are other sensory nerves, but scattered between the fibres and separating them are neuroglia cells. In this respect the optic nerve fibres again resemble the fibre tracts of the brain and spinal cord. All of the nerves attached to the brain and spinal medulla, with the exception of the olfactory and optic nerves are covered with a myelin and a neurilemmal sheath. The entire mass of the white substance of the brain and spinal cord, on the other hand, and the

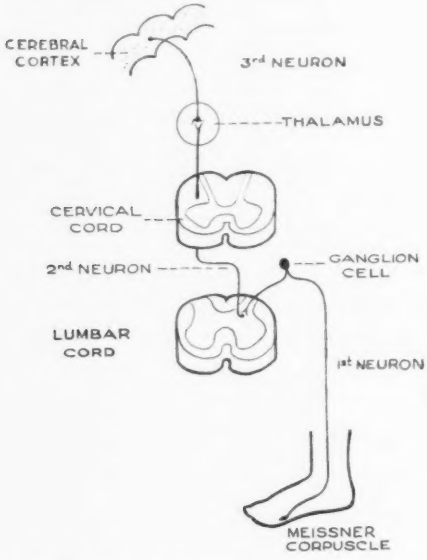

FIG. 1.—Neurons in the pathway of common sensation.

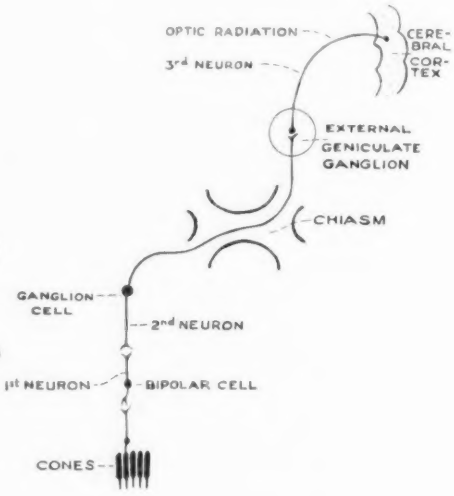

FIG. 2.—Neurons in the visual pathway.

fibres of the optic nerve are formed of myelinated fibres devoid of any neurilemmal sheath. The olfactory nerve fibres have a neurilemmal sheath but are unmyelinated. The optic nerve fibres are therefore not similar in their histological structure to other sensory nerves in the body, but resemble the fibres of the central nervous system.

Myelinization of the optic nerve fibres begins very late. All nerve fibres when first formed are unmyelinated, but most sensory fibres, with the exception of those of the olfactory nerve, soon acquire their myelin coating. The fibres which form the white substanse of the cerebrospinal axis do not acquire their myelin until the fifth month of fœtal life, and although myelinization of the optic nerve fibres begins about this time it is generally not until about the seventh month that this has progressed down the nerve as far as the

lamina cribrosa. The deposit of myelin usually stops at this point, but occasionally it extends beyond the lamina, and the nerve fibres in the retina then appear as semi-opaque white sheets in one or more quadrants adjacent to the optic disk. This constitutes the well-known condition of retained medullated nerve sheaths.

It is evident from the above that the optic nerve is not a true peripheral nerve. It is really one neuron or link in the chain of fibres which runs from the rods and cones up to the occipital cortex. It is interesting to compare the neurons concerned in the pathway for the sense of sight with those of common sensation.

There are three neurons which form the pathway of common sensation. Consider for a moment the various parts of the nervous mechanism which convey the sense of pressure from some point in the skin, for example, in the sole of the foot. In the skin are found special end-organs connected with each sensory nerve ending; the so-called corpuscles of Meissner. These are known as sensory end-organs, and it is in these that the sensation of touch or pressure has its origin. (Fig. 1.) The first neuron in this pathway connects the sensory end-organ to a cell in the posterior horn of the spinal cord. This first neuron runs all the way from the sole of the foot up the leg into the dorsal region of the spinal cord. Near its point of entrance into the cord is the cell-body which governs its nutrition. These cells form the posterior root ganglia. The second neuron starts in the posterior column of the cord and ascends to the thalamus. As this fibre passes up the cord it gradually passes over to the opposite side, and comes to lie in the opposite anterolateral column. The third and last neuron begins with a cell in the thalamus, the fibre running from this point to its appropriate cell station in the temporal lobe of the brain.

In the case of the optic nerve and tracts there are again three separate neurons linked together, extending from the retina to the occipital cortex. (Fig. 2.) The sensory end-organ consists of the rods and cones. The first neuron begins in the outer plexiform or granular layer, and ends in the inner plexiform or granular layer. The cell-body governing the nutrition of this fibre is the bipolar cell, which cells form the inner nuclear layer. This neuron, although extremely short is the true optic nerve in the physiological sense, and corresponds to the long fibre which runs from the sole of the foot up into the spinal cord.

The second neuron in the retina begins in the inner nuclear layer and runs from here up to the primary optic ganglia, *i.e.*, chiefly the external geniculate body. This is the anatomical optic nerve. The cell governing the nutrition of this fibre is the ganglion cell. As this fibre ascends to the external geniculate body most of the fibres cross over to the opposite side. In the more primitive forms of the mammalia all the fibres cross over, similar perhaps to the crossing which was described above in the case of the second neuron for common sensation. In man only about eighty-five per cent. of the fibres cross. The crossing takes place in what is known as the chiasm.

The third neuron runs from the external geniculate body by way of the optic radiations to the occipital cortex.

It is evident that the anatomical optic nerve, which actually is a second neuron or tract in the path of conduction, and not a sensory nerve at all, should suffer from those diseases which commonly affect second order neurons in the central nervous system, and not ordinary sensory nerves. The reactions of the anatomical optic nerve to injury and disease should likewise be those peculiar to second order neurons in the central nervous system.

A further point of peculiarity of the optic nerve as compared with other sensory nerves in the body depends on the fact that the optic nerve is surrounded by prolongations of the sheaths which encase the brain, *i.e.*, the dura, pia, and arachnoid. At the optic canal the dural sheath splits into two layers, one of which lines the orbit as the periosteum, while the other adheres closely to the optic nerve itself, and finally becomes indistinguishable from the outer layers of the sclera after the nerve reaches the eyeball. In other sensory nerves these sheaths only begin where the fibre enters the cerebrospinal axis. The presence of these layers, and the spaces between them and the nerve, account for many of the peculiarities in the pathological reactions of the optic nerve.

These sheaths surrounding the optic nerve are supplied with many sensory nerve fibres. These give rise to pain in inflammatory conditions of the nerve in the orbit, such as occurs in retrobulbar neuritis in the acute stage. The fact that patients with choked disk suffer no pain, although the nerve head itself is œdematous and the fibres pressed upon proves that the pain in retrobulbar neuritis arises from the sheaths and not from the nerve fibres themselves.

Since both the subarachnoid and the subdural spaces are in direct communication with those of the brain these spaces are found to be distended with fluid with the occurrence of increased intracranial pressure. This distention of the optic nerve sheaths and compression of the optic nerve fibres would probably not of itself produce the condition of choked disk were it not for the fact that the central retinal artery and vein cross through this space as they enter the substance of the nerve in the orbit. The nerve is penetrated about ten millimetres behind the globe by these vessels, and Fry finds that the vein frequently runs along the sheath for some distance before entering the nerve. This allows the vein to suffer from compression if fluid is backed up in the intervaginal space, and accounts for the stasis and œdema of the nerve head which characterizes the condition known as choked disk. As the pressure rises in the sheath the veins are compressed, leading to venous engorgement, capillary stasis and outpouring of serum. The pressure in the intra-ocular veins gradually rises, and the return circulation will go on as long as the blood can be forced through into the cavernous sinus. A point is finally reached, however, where the pressure in the intervaginal space is sufficient to strangulate the veins. The result is similar to

the strangulation of a hernia. All return circulation, as far as the central retinal vascular system is concerned, is stopped. The circulation of the interior of the eyeball is still carried on by the chorioidal system, since these vessels never enter the optic nerve sheaths, but traverse the orbit outside the nerve on their way to and from the globe.

An objection to this conception of the mechanism by which choked disk comes about is the fact that we do not find typical choking in cases of thrombosis of the central retinal vein. Instead we meet with massive hæmorrhages surrounding the disk. It is possible, however, that this is because the circulation in this latter condition is stopped relatively suddenly, so that there is no time for œdema to develop. The pressure in choked disk is applied to the veins over a long period of time and very gradually. Choked disk cannot be produced experimentally by sudden stoppage of the circulation but only by gradual and long continued pressure.

In addition to the peculiar features mentioned above which the entrance of blood-vessels into the nerve bestows upon the optic nerve, the presence of this rich vascular network assures the nerve a very large supply of blood. In its course through the optic nerve the central retinal artery gives off numerous branches anteriorly and posteriorly which supply the fibres with nutrition. It is possible that the main function of this particular vascular system is to nourish the optic nerve fibres. This may be surmised from the fact that the vascular supply is extraordinarily rich, especially at the intra-ocular end of the nerve, where the retinal system anastomoses with branches of the chorioidal system to form the circle of Zinn, and from the fact that the chorioidal circulation is amply sufficient to take care of the outer layers of the retina. As a matter of fact it is well known that the capillaries from the retinal system do not penetrate into the retina any further than the inner nuclear layer.

The rich capillary network on the surface of the disk accounts for the characteristic color of the normal disk as seen through an ophthalmoscope. Hyperæmia of the disk is due to an increased filling of the capillaries, and pallor of the disk is due to a decrease in either the number of capillaries, or to their size, or to their hæmoglobin content. The disk is normally paler in advancing years than in youth due to the gradual sclerosis of the vessels, and an advanced arteriosclerosis often leads to a marked pallor of the disk.

Pallor of the disk may also be due to an overgrowth of glial tissue on the nerve head. It is possible that the different color which characterizes the various forms of optic atrophy may be due to the relative preponderance of these two factors, *i.e.*, overgrowth of glial tissue and loss of capillarity. The porcelain white disk of tabetic atrophy, with exposure of the lamina cribrosa, is probably due to a very marked disappearance of the capillaries on the disk. The dirty white disk in post-papillitic atrophy with filled-in cup and blurred disk margins is due to loss of capillarity with remaining œdema and deposits of fibrin and cellular débris, while the waxy disk seen in pi-

mentary degeneration is thought to be due largely to an overgrowth of glial tissue.

It is evident that one must not be too hasty in judging the condition of the nerve fibres from the appearance of the disk alone, as a pale disk due to loss of capillarity may not necessarily indicate true atrophy of the nerve fibres.

The optic nerve like all other nerves in the body will degenerate when its connections with the cell-body which governs its nutrition have been severed. Since the optic nerve fibres lack a neurilemmal sheath, however, they are not capable of regenerating. Hence, one cannot expect any recovery of function in cases where the fibres have been severed, or where the ganglion cells in the retina have been destroyed. Once the fibre has atrophied it can never recover. On the other hand, apparent cessation of function may not mean that the nerve has degenerated. Pressure on the nerve from tumors, either in the orbit or inside the skull, may cause great functional embarrassment even to the point of total loss of sight, but when the pressure is removed recovery may be rapid. For such cases the term physiological block, as suggested by Cushing, is very appropriate. The pressure, perhaps by shutting off an adequate oxygen supply to the fibres through the circulation, prevents the passage of the nerve impulse, but does not cause death of the fibre.

Atrophy of the optic nerve is common in tabes, and often constitutes the earliest symptom of the disease. The lesion which produces the typical symptoms is a degeneration of the posterior columns of the cord. The fibres in these columns are first order neurons. One might expect to find the tabetic lesions in the optic nerve in the first order neurons, therefore, *i.e.*, in the bipolar cells and their connections. Although it is very rare that tabetics die early enough for one to obtain the optic nerves in the very first stages of degeneration, the first few cases which have been examined at an early stage do not show the degeneration in the retina or optic nerve close to the eyeball, but high up in the nerve near the optic foramen.

The reason the optic nerve suffers from the tabetic degeneration is probably due to the presence of the optic nerve sheaths. Although the question is by no means settled it is probable that tabes is a pachymeningitis, which affects the sensory nerves close to their entrance into the spinal canal where these sheaths begin. By analogy, therefore, the optic nerve suffers from a similar pachymeningitis, and this is confirmed by the fact that the earliest changes in the optic nerve are always in the periphery of the nerve, where the fibres are in contact with the sheaths.

Summary.—The development and structure of the optic nerve prove that it is not a true sensory nerve but a second order neuron in the central nervous system. This fact together with certain other anatomical and physiological peculiarities explain many of the reactions of the optic nerve to disease.

THE SURGICAL MANAGEMENT OF BRAIN ABSCESS

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The management of brain abscesses still appears to be in a state of confusion. Many surgeons are in doubt when to drain an abscess and are uncertain concerning the procedures to use. We believe a review of our experiences at the clinic might therefore offer some assistance in the management of such abscesses.

Cerebral abscess results from intracranial invasion of pyogenic organisms from acute or chronic infection of the middle ear, or frontal or accessory nasal sinuses, from compound penetrating injuries to the skull, and from infected emboli associated with such chronic suppurative lesions as osteomyelitis and empyema or purulent bronchiectasis. A history of initial infection with subsequent extension to the brain usually can be elicited. This is characterized by symptoms of meningitis or localized encephalitis, with or without an elevation of temperature, which in progressing produces signs of intracranial pressure. The three stages in the development of a cerebral abscess are (1) the initial stage of localized meningitis and encephalitis, with spontaneous recovery or progression to the second stage; (2) the quiescent stage, with encapsulation and liquefaction necrosis, and (3) the terminal stage, with recovery or death. Recovery may occur spontaneously with inspissation or resolution of pus, or it may occur following surgical drainage. Death ensues as a result of rupture of the abscess into the subarachnoid spaces and ventricle, or into adjacent brain tissue, with further extension of the lesion. The most expedient time for surgical treatment is during the second, or quiescent stage, and the success of the procedure depends on adequate and thorough drainage.

The diagnosis and treatment of brain abscess has been gradual in evolution, the earlier pathologists distinguishing between purulent and non-purulent encephalitis. Recognition of the etiological factors associated with abscess of the brain by Toynbee[33] in England in 1855, and by Biermer in Germany in 1867, opened a new avenue of investigation. Clinical investigation was begun by Wernicke,[35] whose pioneer work on aphasia augmented our knowledge of the diagnostic possibilities and the peculiar symptoms produced. Barker,[7] Horsley,[23] and Ballance[6] were among the pioneers who attempted to deal with brain abscess by means of surgical interference. In a classical contribution, Macewen,[29] in 1893, presented a summary of the essential features in diagnosis and treatment advocated at that time. Warrington,[34] in discussing the etiological factors of brain abscess, divided the methods of

invasion of the cranial cavity by the infecting organism into two major groups, the more common including foci in contiguous structures. This group included infections following injuries to the skull, in a great many cases resulting from osteomyelitis developing from purulent infection in the mucous membrane lining the cavities in the temporal bones or in the accessory nasal sinuses. The second group of important etiological factors he designated as infections of the brain through the blood-stream from some distant site of suppuration, resulting in metastatic or hæmatogenous brain abscess. In this classification were included osteomyelitis of the long bones, bronchiectasis, pulmonary abscess and empyema, and, in rare instances, pericarditis, infective endocarditis, and so forth.

TABLE I

Evans' Classification of Methods of Invasion

A. Direct extension		
1. Otitis media and mastoiditis		109
a. Purulent thrombosis of the lateral sinus	37	
b. Osteomyelitis of tympanic wall	28	
c. Spread via internal auditory meatus	1	
d. Spread along the adventitial spaces of perforating blood-vessels	43	
2. Suppuration in the nasal cavity and accessory sinuses		12
a. Osteomyelitis of the sinus wall	7	
b. Spread along perineural spaces	3	
c. Spread along veins	2	
3. Following trauma to skull		8
4. Invasion of the brain by malignant growths		2
B. Hæmatogenous spread		
1. Metastatic brain abscess resulting from intrathoracic suppuration		22
a. Chronic bronchiectasis	17	
b. Empyema	5	
2. Metastatic brain abscess resulting from extrathoracic suppuration		24
C. Method of spread doubtful		2
D. Source, and therefore method, of spread doubtful or unknown		15
Total		194

Evans,[17] in a study of 194 cases of brain abscess at necropsy, discussed the etiology under headings depending on whether infection was transmitted to the brain from an adjacent or distant primary focus (Table 1).

Suppurative otitis media is the infection which most frequently leads to intracranial complications, and this results from direct extension of the infective process. Evans stated that 83.2 per cent. of all brain abscesses in his series were the result of direct extension from the middle ear and antrum. Macewen discovered that an abscess may occur independent of a visible tract of inflammation, the organism being conveyed by direct vascular connections. This is either due to an infective thrombosis spreading through the veins into the pia mater or brain or to a reversal of the blood-stream with carrying of portions of the infected thrombus inward. Although chronic otitis media prevails as a causative factor, acute otitis may lead to brain abscess when the infection is a virulent one.

In an anatomical discussion of the regions most susceptible to attack by caries and necrosis Macewen gave precedence to the mastoid region; he placed the roof of the tympanum and antrum second, the sigmoid groove third, the posterior wall of the external auditory canal fourth, the tympanic floor with the posterior wall of the carotid canal fifth, and the petrous portion of the middle ear, including the structures, sixth.

Although brain abscess may occur at any age, it is more common among adults. According to Holt[22] brain abscess is rare in very young children, although Evans reported twelve cases in which the patients were less than five years of age. A survey of the literature reveals that the situation of a brain abscess of otitic origin is as a rule in the temporosphenoidal lobe or in the cerebellum, although a few cases have been reported in which the abscess was found in the occipital and in the frontal lobes. In a series of 645 cases collected by Heiman,[21] 395 abscesses were in the temporosphenoidal lobe and 196 in the cerebellum. Evans stated that brain abscesses, regardless of cause, occur about twice as often in the cerebrum as in the cerebellum, but that when those caused by distinct foci were eliminated, the ratio changed and the frequency with which the lesion was situated in the cerebrum was found to be markedly diminished.

Etiology and Pathology.—Streptococcus pyogenes and Staphylococcus pyogenes aureus, according to Macewen, are the organisms most frequently demonstrated by the microscope and isolated by culture, although besides these organisms pneumoccoci, hæmolytic streptococci, or, though rarely, colon bacilli, may be the infective organism.

Avenues of Infection.—Brain abscesses result from three avenues of cerebral infection: inoculation, extension by contiguity, and embolus.

Inoculation of the brain with septic organisms results from compound, comminuted fractures of the skull, puncture wounds extending through skull into the brain, and gunshot wounds. Fortunately not all wounds result in the formation of abscess. The type and virulence of the organism, as well as natural immunity, play important parts in determining whether or not abscess will develop. The emergency surgical treatment, immediate removal of infected, necrotic brain tissue, may prevent the development of an abscess.

Extension of infection by contiguity is responsible for the largest number of brain abscesses. They follow furuncles, lacerations, and cellulitis of the scalp, and osteomyelitis resulting from infected wounds and extension from nasal sinus and mastoid infections. Again the virulence of the organism and the natural immunity of the patient to the invading organism are important factors in determining whether or not a cerebral abscess will develop. However, the efficiency of the cerebral circulation is just as important a factor as are virulence and immunity, since one rarely sees a cortical abscess when arterial circulation is adequate. Infections may involve the scalp, skull, and meninges without giving rise to a cerebral abscess. This phenomenon, we believe, is due to the fact that meningeal reaction has not resulted in the thrombosis of veins extending into the white substance of the brain. Local

infection of meninges may produce symptoms of meningitis with or without organisms in the spinal fluid.

Cerebral abscesses are invariably situated below the cortex. Occasionally a stalk can be seen to extend from the meninges to the abscess, but more often than not no trace of invasion can be demonstrated. The explanation for this, we believe, is due to the fact that a communicating vein has become thrombosed and has served as a channel for the organism to invade the white, poorly-vascularized brain tissue. The stalk, if present, represents the zone of reaction about the infected vein. Following the development of the infected thrombosed vein there is a localized area of encephalitis. This process extends by thrombosing more capillaries and vessels until immunity and reaction limit the extension. The centre of the process disintegrates, liquefies, and becomes pus. Proliferation in the peripheral zone results in fibrous formation and encapsulation of the pus.

We believe that infections may travel through thrombosed veins and diploë for long distances and produce abscesses without giving rise to local osteomyelitis during their course.[3] This is substantiated by the fact that abscesses result from infections of the frontal sinus, antrum, and superior maxilla. The reason that cerebral abscesses do not always follow osteomyelitis of the flat bones of the calvarium, frontal sinusitis, disease of the middle ear, or mastoiditis is due, we believe, to the fact that venous thrombosis becomes limited and a collateral venous circulation is maintained.

A single embolic abscess is relatively rare. Multiple abscesses follow pulmonary disease, particularly bronchiectasis. These may also represent part of a general septicopyæmia. The infection associated with multiple abscesses is usually so virulent and overwhelming that death results before encapsulation takes place.

Bagley[4, 5] in a comprehensive pathological study of brain abscess, divided the avenues of infection into four groups. Hassin,[20] in a study of the histopathology of brain abscesses, classified them under the two general headings, acute and chronic, making his differentiation on the formation of a fibrous wall consisting of three layers. He stated that in acute abscess, in which the reaction of the brain tissue, in diffuse suppuration, has not had sufficient time to become encapsulated, there is a tendency toward total destruction of ganglion cells with partial destruction of the nerve fibres and the glial cells (observed also by Cone[12]) and toward progressive vascular changes consisting in hyperæmia and thickening with infiltration of the vessel walls. In chronic abscess, wherein the process has been of sufficient length to allow the formation of a capsular wall, the changes are characteristic. The fibrous capsule derives its structure from the lymphocytes of the blood by formation of fibroblasts which continue to accumulate until the local area of infection is surrounded and walled off.

Penfield[32] stated that the wall of an abscess begins to form in the first week but that it is not firm enough to offer appreciable resistance to an exploratory needle until two to three weeks have passed. The course without

drainage depends on the nature and virulence of the organism. If an insufficient wall or capsule is not formed, spreading encephalitis with œdema of the brain may quickly terminate the patient's life.

Symptoms.—The symptoms of cerebral abscess vary with the different stages of the disease and vary according to the systemic reaction, the degree of increased intracranial pressure, and the situation of the abscess.[31]

Initial Systemic Symptoms.—Patients with temporosphenoidal or cerebellar abscess invariably give a history of chronic otitis media or acute otitis media which suddenly stops draining or of the development of a suppurative mastoid. Abscesses in the frontal lobe are preceded by acute colds, frontal sinusitis, pansinusitis, and osteomyelitis of the frontal bone. The sudden increase in septic reactions plus cerebral involvement of patients with cranial wounds, osteomyelitis of the skull, and general pyæmic infections, including bronchiectasis, suggest the development of a cerebral abscess. Patients become apathetic and an increase in temperature develops; the temperature remains high for the first few days but soon takes on the septic, steeple-like curve. The leucocyte count jumps to 20,000 or more per cubic millimetre. Examinations of spinal fluid disclose an increase of pressure, increased protein, and an increase of lymphocytes.[37] If an active suppurative meningitis develops, polymorphonuclear leucocytes appear in large numbers, causing the fluid to become cloudy. The active organisms also are usually identified.

Initial Cerebral Symptoms.—Headaches and vomiting appear early among the symptoms. Irritability, alternating with a stupor and with rigidity of the neck muscles, are signs of increased intracranial pressure and meningeal irritation. The pulse is full, bounding, and slower in rate. Choked disks and retinal hæmorrhages likewise appear when the normal flow of cerebrospinal fluid has been disturbed.[8, 28]

Initial Localizing Signs.—The localizing signs depend on the size and situation of the abscess. A *temporosphenoidal abscess* can produce homonymous field defects, homolateral palsy in the distribution of the sixth and third cranial nerves, and contralateral anæsthesia, paralysis, and pathological reflexes. An *abscess in the frontal lobe* may attain considerable size without producing localizing symptoms.[24] However, we have observed that the initial swelling about one eye is a good diagnostic sign of the lobe affected since the abscess is usually on the same side. Osteomyelitis of the frontal bone invariably extends to one or the other sides of the median line, which suggests the lobe involved. Although paralysis may not be present, reflexes may be exaggerated on the contralateral side. When in doubt, one is justified in carrying out ventricular study and ventriculography. *Cerebellar abscesses* produce ataxia of the cerebellar type, plus nystagmus and reduction of homolateral reflexes. Hiccoughs and rigidity of the neck further indicate a lesion of the posterior fossa. Those *miscellaneous abscesses* that involve the brain stem and pons present bilateral pyramidal signs and bilateral palsy in the distribution of cranial nerves. Those developing from infected wounds are situated in the vicinity of the infection, and those developing from nasal

sinuses other than the frontal sinus are situated in the lower half of the frontal lobes.

We have seen *temporosphenoidal abscesses* and one *cerebellar abscess* produce homolateral pyramidal symptoms with partial contralateral pyramidal symptoms. The symptoms all disappeared following drainage of the abscess. The homolateral pyramidal symptoms were undoubtedly due to partial displacement of the hemisphere by the abscess to the opposite side to such an extent that the crus cerebri was pressed and notched by the opposite margin of the tentorium at the incisura tentorii.

Secondary Symptoms of Quiescent Stage.—The pathological process, during the initial stage (up to three weeks), represents a battle between destructive and reparative forces. The secondary quiescent stage, second to fifth week, represents a partial victory for the forces of repair, since the abscess no longer enlarges and the pus is becoming more securely confined by a fibrous capsule. The œdema disappears and circulatory disturbance, peripheral to the capsule, is slowly repaired. The recovery will continue up to five weeks, with large abscesses, when it apparently comes to a standstill. During this quiescent stage the symptoms of sepsis subside, and the temperature and leucocyte count recede to normal or just slightly above normal. Headaches improve, mental reactions are faster, and the cerebrospinal fluid count returns to normal. Localizing symptoms likewise subside, but in spite of the general improvement periodic headaches occur, and choked disks and field defects fail to disappear. Reflexes remain exaggerated and motor impairment persists. In cases of abscess of the frontal lobe, symptoms of euphoria or depression linger. The leucocyte count continues to rise to 12,000 or 14,000 per cubic millimetre. The patient has days when he is apathetic and refuses to eat, and prefers to lie in bed. If it were not for the history of the infection and the symptoms of the initial stage, it would often be difficult to distinguish those due to abscess from those produced by a cerebral neoplasm.

Symptoms of the Terminal Stage.—Symptoms may continue on from the quiescent stage for months until the patient is operated on through an erroneous diagnosis of brain tumor or dies from rupture of the abscess into the ventricular system or subarachnoid spaces.[19] Small abscesses heal spontaneously with disappearance of all symptoms. Symptoms of abscesses that have been drained surgically disappear unless important tracts and cortical centres have been destroyed by the inflammatory process. Mutilating operations likewise contribute to permanent injury of cerebral tissue. Epilepsy is a sequel to localized encephalitis and abscess, and it may appear in any case in which there has been a lesion in the frontal, temporal, or parietal lobes. The incidence of this condition may be lowered by proper and adequate drainage. Subsequent scar resection may offer some amelioration from this symptom.

Surgical Considerations.—Appropriate Time for Drainage.—It took us many years to learn that hasty emergency operations were futile and were

accompanied by high mortality.[1] This, undoubtedly, was due to the insistence of colleagues that we do something as soon as a diagnosis of cerebral abscess had been made. Every cerebral abscess passes through a stage of encephalitis before encapsulation.[11] It is during this stage that the infection is virulent and is most easily disseminated. Some surgeons argue that unless the necrotic tissue is removed the patient will die. This is true in the occasional case, and cases have been reported in which aspiration of necrotic material was successful; more often than not, however, the infection is disseminated by surgical intervention and the patient dies from a fulminating, suppurative meningo-encephalitis. We believe the best procedure to employ during the acute stage is supportive treatment, rest in bed, high calorie diet, spinal drainage, ice bags to the head, frequent catharsis, moderate amounts of fluids, and, if the patient is comatose, occasional intravenous administration of hypertonic glucose.

Encapsulation takes place in two to four weeks. The process is an indication that immunity is being established. It is characterized by a fall in the leucocyte count from 20,000 or more to 12,000 or 14,000 per cubic millimetre. The temperature likewise returns approximately to normal, 100° F. or below. The cell count of the cerebrospinal fluid, if increased, returns to normal. The cerebral symptoms gradually subside, but seldom completely disappear until the abscess is drained. Choking of the optic disks, if present, may continue until optic atrophy results. When encapsulation and immunity have been established, thorough and continuous drainage is necessary to effect a cure without recurrence of the abscess.

SURGICAL TECHNIC

The ideal exposure of a cerebral abscess is one that allows the surgeon to enter the cranium through a clean field over the abscess. Exceptions to this rule are when one wants to avoid a scar in the frontal region or is compelled to pass through a zone of osteomyelitis to reach the abscess. In entering the skull through a clean field the site is chosen where the abscess is nearest to the cortex or will give the best drainage. A small incision, 5 centimetres in length, is made in the scalp (Fig. 1). A craniotomy 3 centimetres in diameter (Fig. 2) is usually large enough to afford ample exposure. The meninges and cortex are then sutured with interrupted stitches of catgut about the margins of the incision in the skull to prevent separation of the cortex from the dura (Fig. 3). A crucial incision is made in the dura to expose an area about 2 centimetres in diameter. The meninges and cortex are further sealed and glued together with the electrocoagulating current, about the margins of the incision in the skull, a suggestion of Learmonth's, to protect further against spread of pus over the cortex under the dura. The margins of the wound are covered with wet cotton strips. The cortex overlying the abscess is frequently œdematous and cyanotic in appearance.

A round-tipped brain cannula is used to locate the abscess. The resistance

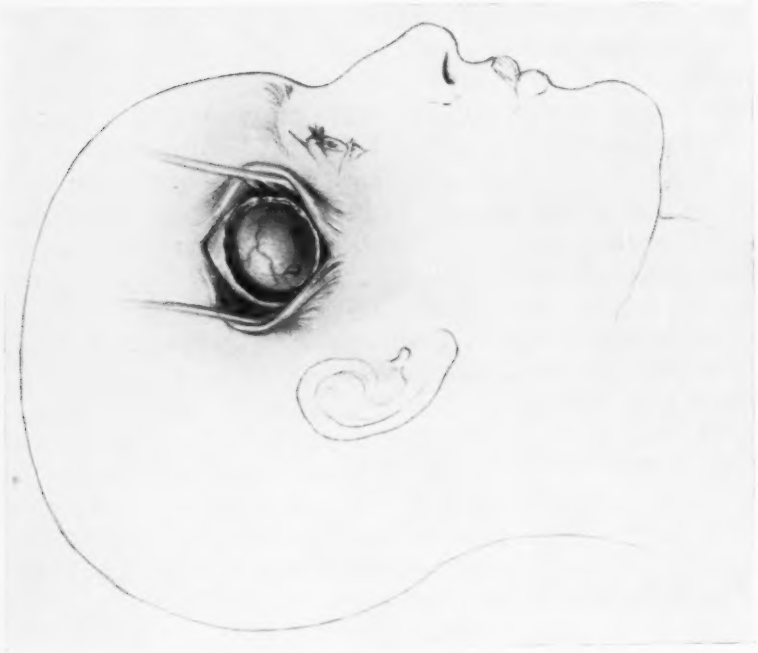

FIG. 2.—Craniotomy illustrating the dependent position for draining an abscess of the right frontal lobe.

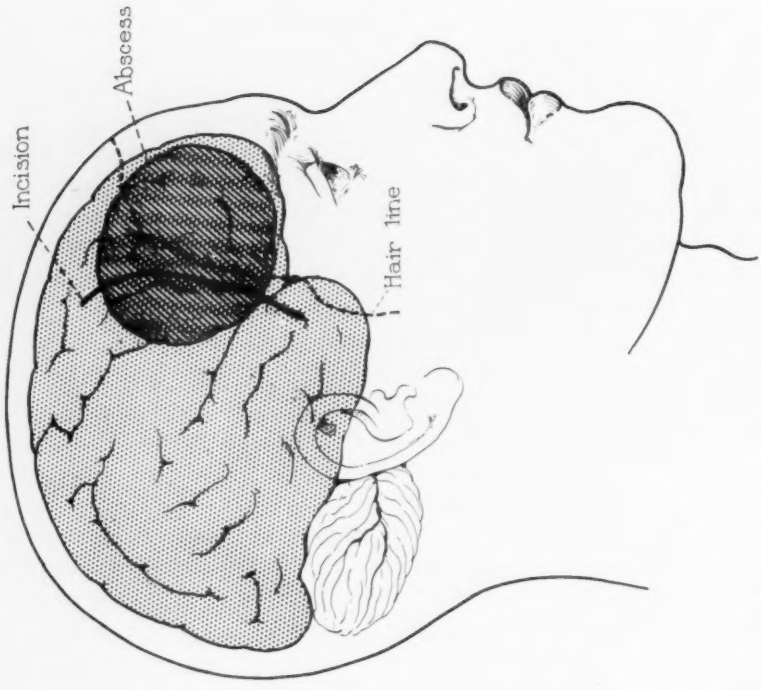

FIG. 1.—Incision in scalp for abscess in the right frontal lobe.

of the capsule of the abscess gives one the impression that the cannula is being placed against a flexible, hollow, rubber ball. If the abscess has been there for a long time, the resistance may be so great that it is impossible

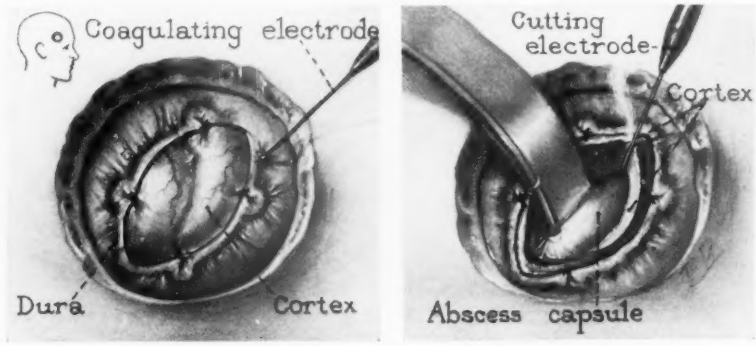

FIG. 3.—*Left.*—Procedure in sealing meninges to cortex with interrupted sutures of catgut and electrocoagulating needle. *Right.*—Incision of cortex exposing capsule of abscess.

to penetrate the capsule without incising it with a bistoury. Small abscesses may be overlooked, since the firm capsule is capable of deflecting the cannula unless the cannula is directed toward the center of the abscess. As soon as the cannula enters the abscess, the trochar is removed and a Luer's syringe

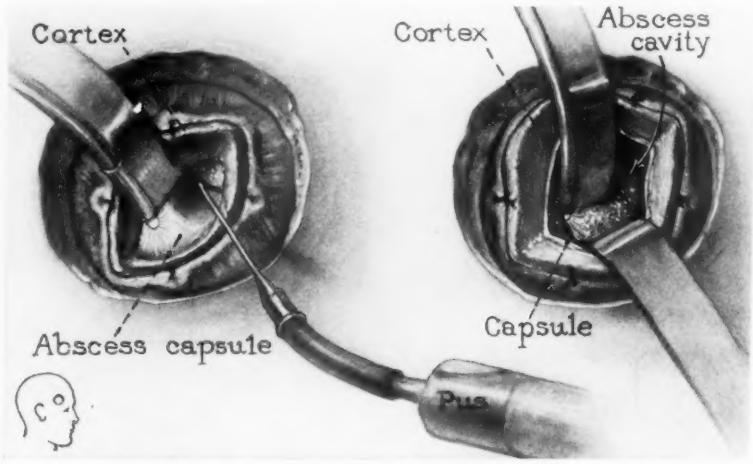

FIG. 4.—*Left.*—Partial aspiration of pus with cannula before incising capsule of abscess. *Right.*—Exploration of abscess and cleansing of abscess cavity.

with an intervening rubber connecter is attached to the cannula. The pus is gently aspirated, and the cavity is cleansed with small quantities of normal saline solution (Fig. 4). The cavity of the abscess is explored by incising the cortex and capsule with an electrosurgical needle, using the cannula, which has been left in place, as a guide. The capsule is opened for a distance of 2 centimetres in order to insert an illuminating retractor. This makes intracapsular exploration possible, permits further cleansing of the cavity of the

abscess, and assures against overlooking communicating abscess pockets. During this procedure the retractor is used to hold the superficial wall of the capsule and the cortex against the skull.

To assure further against collapse of the cortex following drainage of an abscess, we fill the cavity about the two inserted tubes with loosely packed,

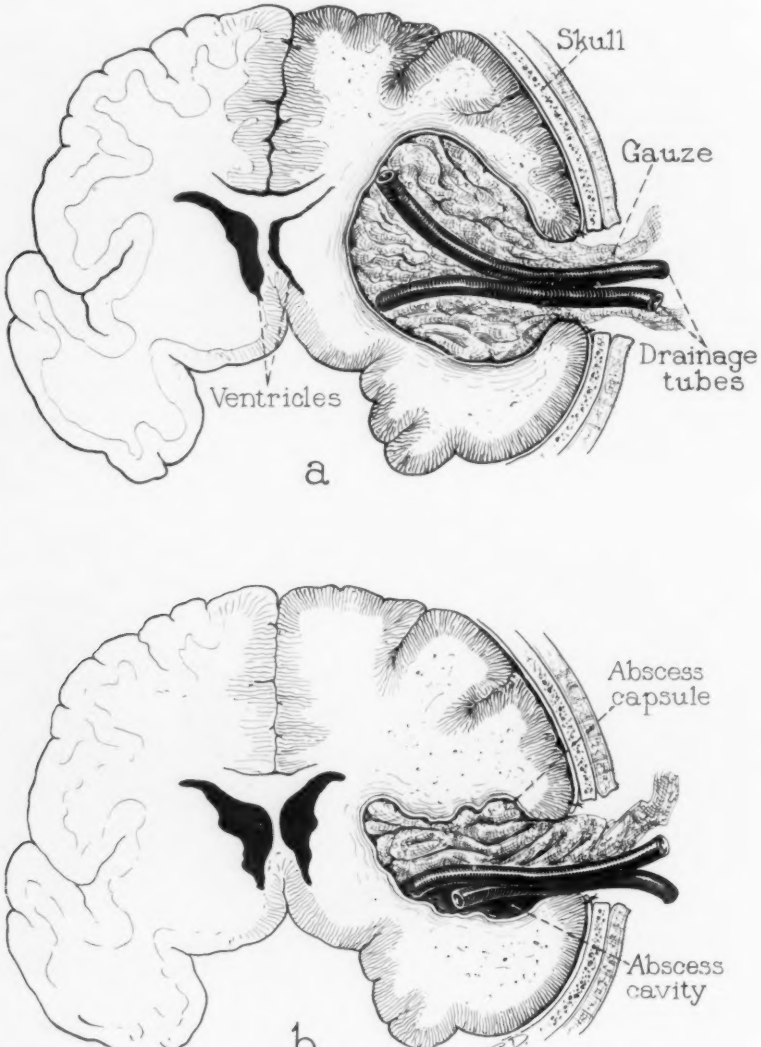

FIG. 5.—*a*.—Method of draining abscess cavity to assure adequate drainage and prevent pocketing of abscess cavity. *b*.—Gradual withdrawal of drainage material and resulting collapse of the abscess capsule.

iodoform gauze strips (Fig. 5). These continue to keep the capsule moderately distended, instead of allowing it to crumple down and give rise to loculated pockets within the capsule. The gauze strips are shortened daily until they are removed on the tenth day; this permits gradual collapse and

contraction of the capsule and prevents recurrence of abscesses and cerebral fungi.

The two tubes are sections of number 18 catheters. They are left undisturbed until after the gauze has been removed. One is shortened on alternating days until removed on the twenty-first day; the other is shortened as the sinus closes in and forces it out, which requires from four to six weeks. At operation the tubes are fastened to the skin to prevent accidental removal during the daily withdrawal of gauze. Following removal of stitches, the tubes are prevented from falling out by transfixing the exposed ends with safety pins and fastening these to the skin with strips of sterilized adhesive tape (Fig. 6). Strips of vaseline gauze are placed over the margins of the wound to prevent gauze dressings from adhering to the wound. The tube drain is occasionally exchanged for a smaller one after the third week, but at no time is the cavity irrigated for fear of disseminating the infection. The patient is allowed to get out of bed after the second day and to leave the hospital after two weeks.

FIG. 6.—Appearance of wound, with one drainage tube in place, four weeks following drainage of an abscess of the right frontal lobe.

An abscess of the frontal lobe that is not associated with osteomyelitis of the frontal bone can be drained through a small opening placed back of the hair line through the frontal bone just above the zygoma. If osteomyelitis is present, one need not worry about additional scars and can then drain the abscess through the region of infection. We have found it safer to remove all suppurating and sequestrated bone before exploring for an abscess, unless there is evidence of an inflammatory zone extending from the dura into the brain. We prefer to cleanse the wound with tincture of iodine or merthiolate and to close it loosely and wait for the superficial infection to subside before proceeding with drainage of the abscess. If the inflammatory zone of the dura extends through into the brain, one might proceed with drainage at the initial operation, first by suturing and coagulating the meninges and cortex about the region to be explored. Instead of inserting the brain cannula blindly into the brain through the infected region, we prefer to incise the meninges and cortex with the electrosurgical needle to avoid contaminating normal brain tissue with the cannula. If the capsule is encountered, the usual procedure is employed; otherwise a gauze pack is placed into the

cerebral wound to afford drainage while such further diagnostic measures as ventriculography are employed. The introduction of a cannula, knife, or needle into normal brain tissue during operation on the mastoid or frontal sinus or for osteomyelitis, is a dangerous procedure, since it will give rise to encephalitis and will cause more abscesses to be formed than would be accidentally found by such procedure.

Drainage by Aspiration.—Aspiration by needling has a limited field of usefulness. It is most useful in draining small, deep-seated abscesses. An aspiration or two may be sufficient to drain a sterile abscess, but when the organism still remains active, refilling continues until adequate, continuous drainage has been instituted. There is also danger of spreading the infection by repeated aspiration, as it is impossible to insert and withdraw the needle through the same tract.[13]

Drainage in Two Stages.—Dowman[14] and others have advocated operation in two stages for the purpose of allowing the brain to herniate through the opening in the skull before opening the abscess. With herniation, adhesions are supposed to be formed, preventing the cortex from separating from the wound margins and meninges when the abscess is evacuated at the second stage. Unfortunately this does not always occur, and contamination does take place during drainage. There is danger too that the brain may prolapse through the craniotomy opening, during the interval between the two stages, and give rise to an extensive cerebral fungus. An operation in two stages is most useful when it is necessary to treat active osteomyelitis before exploring for a cerebral abscess. In such circumstances the dura should not be opened until the second stage, and it should then be sealed to the cortex about the field to be explored with interrupted stitches of catgut and the electrocoagulation current in order to prevent any spread of the infection.

Treatment of the Capsule.—Again we find surgeons divided in their opinions as to the best treatment of the capsule. It must be accepted that if the capsule is left in place, it will result in a fibrous scar. Although this does occur, can it be avoided, and should the capsule be removed at the initial operation or allowed to remain unless symptoms of epilepsy appear? Macewen, Bagley, Hassin, Cone, and many others, have demonstrated the pathological changes that develop to form a capsule about the abscess. From our clinical experience it is apparent that the capsule continues to thicken for several months if the abscess goes unrecognized. Therefore, it is fair to assume that the walls will more readily collapse and be less thick if the abscess is properly drained as soon as immunity and encapsulation have taken place. To assure collapse of the capsule, King[25, 26] and Cahill[9] have suggested the removal of the overlying cortex and the peripheral dome of the capsule. King and others have suggested removal of the capsule at the initial operation. This procedure hastens recovery when it is possible to remove the abscess and capsule without opening it. Bagley reported such a case, and one of us (Adson) removed such an abscess but was unaware that he had done so until the mass was opened after removal. The wound in this

case healed by primary intention, without any drainage. Our experience with removal of capsules following evacuation of the pus, however, has not been satisfactory, since a secondary suppurative encephalitis develops that is more troublesome to treat than the original infection. If drainage is not instituted, pus becomes inspissated and forms the caseous centre of a fibrous mass. The mass will gradually contract until there remains but a small nodule of what once was an abscess of 3 to 5 centimetres in diameter. The larger abscesses are more apt to rupture into the subarachnoid spaces and ventricular system than the smaller ones; consequently, it is unsafe to wait for these to disappear spontaneously. We cannot concur with those who believe that the rigid capsules will not collapse, for our experience has demonstrated that all have collapsed if properly drained. The difficulty encountered with recurrent abscesses, attributed to failure of the capsule to collapse, we believe is due to failure to secure adequate and continuous drainage, which has previously been referred to. Epilepsy develops too often following abscess, but a third of our patients complained of epileptiform seizures before operation. Hence, epilepsy is a symptom and a sequel that will be encountered in the treatment of suppurative diseases of the brain. Medication and diets offer some assistance in the management of epilepsy, but we are gradually becoming convinced that secondary operations, scar resections, as practiced by Penfield, are indicated in selected cases a year or later following the initial operation.

Temporal (via mastoid) Drainage of Abscess of the Temporal Lobe.—Abscesses that develop in the temporosphenoidal lobe are the result of extension of an infection from otitis media and mastoiditis with involvement of the antrum and tympanic wall. The infection may travel by contiguity, involving the meninges and brain over the inflamed bone, along blood-vessels, or through thrombosed infected veins. The latter is especially likely in the presence of a purulent thrombosis of the lateral sinus. Since the roof of the tympanic cavity is the thinnest of the communicating aural cavities, it represents the vulnerable spot where pus may first reach the dura. Extradural abscesses may appear without the development of a cerebral abscess. A serous meningitis often accompanies these phenomena, since the dura serves as an excellent screen to prevent sudden inward invasion of the organisms. However, if the virulence of the organism is too great, a septic meningitis with or without an accompanying encephalitis, develops. Frequently the meninges and cortex become so densely adherent to the diseased bone that only a localized meningitis with encephalitis develops, which gives rise to very mild meningitic symptoms, with low cell counts and no organisms in the cerebrospinal fluid. The particular situation of the abscess depends chiefly on the vein thrombosed and the depth to which the infection may travel. This undoubtedly explains why abscesses are found separated from their source of infection and vary in size and situation. Though the source of the infection may be the same, abscesses occur in the temporosphenoidal lobe more often than in the cerebellar lobes. Evans said that the ratio was

3:2, but our experience has indicated that the ratio has been 5:1, which is so high that when we are in doubt as to the situation of the abscess, we always explore the temporal lobe before exploring the cerebellum.

Since these abscesses arise from infections in or about the ear, the question is frequently raised as to whose province they belong, the otitic surgeon's or the nerosurgeon's. Fortunately this is not a serious question when coöperation between the two is maintained at all times. At the clinic, decision is based more on the type of abscess found. Following a radical mastoid operation the dura is carefully examined. If symptoms suggest cerebral involvement, it is determined whether or not the meninges and brain are adherent; if they are, the otitic surgeon incises the mass, extending the incision into the cortex in the hope of encountering an abscess which he then drains and treats. On the other hand if he exposes a clear arachnoid, he stops intracranial exploration and does not contaminate the brain by introducing an instrument from an infected mastoid wound into clean, normal, brain tissue. If symptoms continue, a separate craniotomy through a clean field is performed at a later date by one of the neurosurgeons. Whenever there is doubt as to the necessity for a mastoid operation as against craniotomy for cerebral abscess, the mastoid operation is performed first.

Relation of Frontal Sinusitis to Abscess of the Frontal Lobe.—Frontal sinusitis rarely gives rise to a cerebral abscess without being responsible for an accompanying osteomyelitis of the frontal bone. Woodward,[36] in considering the etiology and pathology of osteomyelitis of the frontal bone, has agreed with others that Staphylococcus pyogenes aureus is the organism most constantly responsible for the lesion, and he has stated that infection of the frontal sinus occludes the ostium and places the pus under pressure. This diminishes the blood supply, which in turn gives rise to necrosis of the mucous membrane and to thrombosis of the perforating veins. From this point the infection spreads through the diploë, preceded by thrombosis of diploic veins wherever death of bone has occurred. Pus and granulation tissue fill the diploë, which results in rapid destruction of the osseous elements. Furstenberg[18] has regarded the frontal sinus as eroded diploë, the outer wall corresponding to the external plates and the internal wall to the internal plates of the frontal sinus, which he believes is the chief reason for extension of the infection of the frontal sinus into the diploic spaces. Again we find the development of a cerebral abscess dependent on the circulation of the brain, for in ten of nineteen cases of frontal osteomyelitis observed in the Clinic abscesses were found in the frontal lobe. In the remainder the dura served as a barrier and prevented invasion of organisms, or the communicating veins had not thrombosed. The sinus infection is considered the emergency disease unless osteomyelitis of the frontal bone is fulminating in character, in which event both need immediate attention. Extradural abscesses over the frontal lobes are uncommon but they occur frequently enough to be watched for. Abscesses of the frontal lobe do develop from infections of the frontal sinus without an accompanying osteomyelitis, just as they develop from infection

of the antrum or ethmoid and from infection of the maxilla following extraction of teeth.[27] These infections undoubtedly follow perivascular spaces and thrombosed veins which formerly drained, and extend into the white substance of the brain. Since these abscesses are usually single, it is not reasonable to expect the infection to be carried by the arterial circulation, for when it is, the embolic implants result in multiple abscesses. The treatment of this group of abscesses devolves on the neurosurgeon, since osteomyelitis may require an extensive cranial operation.

Relation of Extensive Osteomyelitis to Cerebral Abscess.—Osteomyelitis is considered the emergency disease since the infection will spread through diploë and emissary veins unless pressure is relieved. Small stab wounds are better than none, but if a cure is to be obtained, large flaps of scalp need to be reflected to remove thoroughly all suppurating and dead bone. In some instances only the outer table will be diseased, whereas in others the full thickness of the skull is involved. When this is true one should not hesitate to remove all the diseased bone, even though the dura is exposed; the wound should be cleansed with tincture of iodine and the scalp closed loosely, continuing with a similar area in three or four days. The procedure should be repeated until all the diseased bone has been removed. One can clean up a fourth of the skull area at one operation without undue surgical risk. After osteomyelitis has been brought under control, a separate incision may be made over the cerebral abscess and the abscess treated according to the technic described.

Cerebral Abscess of Traumatic Origin.—*Preventive Treatment.*—The débridement procedure in compound comminuted fracture of the skull may readily forestall development of a cerebral abscess. It should be conducted with gentleness to avoid unnecessary injury to the brain and blood-vessels. Foreign particles, spicules of bone, blood-clots, and necrotic brain tissue should be removed by an aspirator. Prolapsed portions of the brain should be resected, and contaminated spicules of skull should be rongeured away. Necrotic margins of skin are removed before the edges are closed loosely with interrupted, non-absorbable sutures. Antiseptic solutions of iodine or merthiolate offer additional protection. Rubber-tissue drains can be used when indicated.

Puncture wounds lend themselves less to emergency treatment as they usually result from penetration of a sharp article through the orbit or nasal sinuses.

Débridement can be used for some gunshot wounds to advantage, but the ordinary bullet wound had better be left alone unless there is evidence of progressive bleeding, in which case emergency exploration is indicated.

Treatment by Drainage.—Such procedures are carried out very much as are those outlined under "surgical technic" except that exploration is usually made through the field of contamination whenever possible. The same principles of supportive treatment are employed as are used in the management

of abscesses of the temporal and frontal lobes resulting from disease of the middle ear or from infections of the frontal sinus.

CEREBELLAR ABSCESS.—Cerebellar abscesses have been the most difficult to treat of all cerebral abscesses since collapse of the cerebellum following drainage usually results in contamination of the subarachnoid spaces and gives rise to a fatal meningitis.[10, 14, 15, 16] It is our treatment of this group of abscesses that has convinced us that the surgically sealed cerebral wound has a useful place in the treatment of brain abscesses. The usual preparation and delay is employed to make sure that encapsulation has taken place. It may be true that the zone of inflammation and adhesion is situated along the sigmoid sinus or petrous bone, but we have found it most advantageous to explore the cerebellum at the most accessible place, which is over the dorsum of each cerebellar lobe. A straight incision in the skin 3 centimetres to either side of the median line, will expose the occipital prominence. The technic from this point on is similar to that previously described. One cannot rely on electrocoagulation alone to seal the meninges and the cortex but must include numerous interrupted stitches of fine catgut to transfix the meninges and cortex around the margins of the proposed cerebellar exploration. There must be no leakage of cerebrospinal fluid. The cannula should be directed in an outward direction to avoid entering the fourth ventricle. Otherwise, the standard technic is used.

PSEUDO-ABSCESS.—The term "pseudo" is used to designate a process that has progressed in a manner similar to the average cerebral abscess except that spontaneous recovery takes place instead of necrosis, liquefaction, and pus formation.[2] The avenues of infection are the same. The systemic reactions and the development of ophthalmological and neurological symptoms are not unlike those of abscess. Clinically the syndrome is similar to that of abscess.

Treatment should continue along supportive lines, but as long as a differential diagnosis cannot be made definitely without exploration, we have employed the routine surgical technic. On insertion of the cannula, resistance has been less marked than that of normal brain tissue, although at no time was pus obtained or a capsule encountered. Microscopical examination of aspirated material reveals some evidence of degeneration and infiltration of small, round cells and leucocytes. When the brain presented evidence of increased intracranial pressure, the small craniotomy has been enlarged, as for cerebral decompression, which has been most effective in decreasing choked disks. The failure of the localized encephalitis to become suppurative is due to a low grade of infection, to high immunity, or to a highly vascularized brain. We have encountered seven such cases and have performed exploratory operation in all of them without a fatality. All patients recovered except one who is occasionally troubled with an epileptiform seizure.

One additional case can be added in which there was circumscribed leptomeningitis with accumulation of purulent fluid in the sylvian fissure that

produced all the signs and symptoms of abscess in the temporal lobe. Recovery following drainage in this case was prompt and permanent.

Doubtful Diagnosis.—All patients with symptoms suggesting brain abscess should be suspected of having a brain abscess and should be treated accordingly. Many of these patients recover without surgical intervention. Localized encephalitis clears up in some cases and small abscesses become fibrosed in others. Those patients who improve but fail to recover completely should be subjected to exploratory operation, for it is much safer to perform a small exploratory craniotomy than to let the patient continue with his symptoms, since large abscesses may rupture into the ventricular system or give rise to new extensions. In five instances we encountered a cerebral abscess when the history of infection was lacking and the patient was sent to operation with a diagnosis of cerebral neoplasm.

Review of Cases.—We have just completed a clinical and post-mortem review of cases in which patients were treated at The Mayo Clinic for cerebral abscess. Altogether ninety-seven patients were treated in the neurosurgical department by five different surgeons. Epidural abscesses about the petrous bone and those cerebral abscesses treated by the otitic surgeons are not included. Sixty patients were males, thirty-seven females. The average age was twenty-four years. Three patients were less than three months of age. Forty abscesses were situated in the frontal lobe, thirty-six in the temporosphenoidal, two in the occipital, and thirteen in the cerebellar. In the remaining six cases the abscesses were distributed miscellaneously.

The invading organisms were identified as Staphylococcus albus or aureus in nineteen cases, Streptococcus hæmolyticus in eleven, Streptococcus viridans in two, a combination of Streptococcus hæmolyticus and Streptococcus viridans in one, and as an unclassified form of streptococcus in five. There was a pneumococcal infection in one, pneumococci with diphtheroid bacilli in one, colon bacilli in one, streptococci with staphylococci in two, and bacilli of tuberculosis in one. In fifty-four cases laboratory reports were lacking or the culture was reported negative.

The review of chief complaints and past and present illnesses coincides with other similar reports. Headache was present in seventy-nine cases, nausea and vomiting in sixty-one, choked disks in forty-nine, and blindness in ten. Fifteen patients had pre-operative jacksonian convulsions and twenty had grand mal seizures. The neurological symptoms varied according to the size and position of the abscess as expected. The degree of recovery was in relation to the injury done by inflammation and surgical manipulation.

The results and mortality afforded an interesting study, as we could compare the handicraft of the various surgeons: 1. The results improved with the experience of the surgeon. 2. The mortality dropped as soon as the surgeon delayed drainage until encapsulation took place. 3. In abscesses of the temporosphenoidal lobes, there was a lower mortality when they were drained through a clean field in the temporal area than when they were drained through a suppurating mastoid wound. There is an occasional excep-

tion, but we believe that all would do better if drained independently of the mastoid wound. The same is true of cerebellar abscesses. 4. The sealing of the meninges and cortex about the drainage tract to prevent contamination has naturally improved convalescence and lowered the mortality. 5. Adequate continuous drainage with gauze packs and rubber-tube drains has prevented recurrent abscesses and cerebral herniation. These statements are substantiated by the recent experience of one of us who had but one death in fifteen consecutive cases of abscess situated above the tentorium, and but one death in three consecutive cases of abscess situated below the tentorium. The two patients who recovered had typical cerebellar abscesses and the one who died had an abscess that extended into the pons from the left cerebellar lobe.

SUMMARY

When cerebral abscesses follow infections about the ear, with indefinite localizing symptoms or with symptoms of conflicting signs of localization, we have observed the rule of exploring the temporosphenoidal lobe before exploring the cerebellum on the side of the infected ear because of the higher ratio of abscesses in the temporosphenoidal lobes than in the cerebellum.

In re-reading the protocols of Macewen's cases of cerebral abscess, we were impressed by the fact that in most of his cases there was a history of cerebral infection of a fortnight or more, which we believe is chiefly responsible for his excellent results, since in his cases sufficient time had elapsed for immunity and encapsulation to have been established before operation was undertaken.

Surgical drainage of an abscess does remove active organisms, but is probably more beneficial in disposing of the intracerebral mass. The arguments for delaying drainage of a cerebral abscess until it is mature, that is, encapsulated, which suggests that immunity has been established, are comparable to those for other inflammatory lesions of the body. One rarely advises drainage of an abdomen for acute peritonitis, although one urges adequate drainage when an abscess has been formed.

We believe, therefore, in administering supportive treatment during the initial stage of infection and in delaying drainage until clinical signs indicate that immunity has been established. We also prefer instituting adequate continuous drainage through a surgically-sealed cerebral wound to the various conservative or ultraradical measures employed.

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CEREBRAL OSTEOCHONDROMA OF DURAL ORIGIN

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The following case is recorded partly because of its rarity, and partly to indicate its origin from the meningeal fibroblasts. In so doing some semblance of order has been given to what might otherwise appear to be an encapsulated tumor wholly unrelated to the other encapsulated tumors of the cerebrum. At the same time it has been rescued from the large group of tumors of unexplained origin.

Case Report.—Motor and sensory jacksonian convulsions involving the right leg and trunk for three years in a man of forty-nine. Increasing frequency of attacks with eventual involvement of right arm. Examination revealed marked weakness of right leg and slight weakness of right arm with increased leg reflexes, ankle clonus and Babinski. Position sense was disturbed in the right hand and toes. Fundi showed no papillœdema; spinal-fluid pressure was seven millimetres mercury. A calcified tumor of the left parietal area was seen by X-ray. At operation a large calcified tumor attached to the falx along the longitudinal sinus was removed. It lay behind the central fissure. It was an osteochondroma. Improvement after operation. Recurrence four years later with a second removal of a similar tumor which was this time diagnosed chondrosarcoma. Improvement followed. Three further admissions for irradiation. Final admission six years after first operation, nine years after onset of symptoms, with recurrence of tumor seen in X-ray and with right hemiparesis. Removal of tumor. Death.

History.—The patient, a man of forty-nine, was admitted to the service of Dr. W. G. Spiller in the University Hospital in May, 1921, complaining of jerking and lameness of the right leg. He had been well until September, 1918, when he awoke one morning with a numb feeling in his right leg. Almost immediately after this his right leg began to jerk, followed by a sensation of jerking of the entire right side of his body. He thinks his right arm jerked, but is sure the face did not. The jerking continued violently for ten minutes, then ceased, only to begin again. After it ceased he felt numb over the entire right side of his body, a sensation which soon passed away. The next day the only residual was a feeling of heaviness in his right calf.

One month later he experienced another attack involving the right leg. This began first with a throbbing sensation in the entire right leg, followed by a jerking which lasted four to five minutes, starting first in the foot and extending up the leg. This was followed by a few twitches in the right shoulder and chest. Attacks of this sort came on every month following this, preceded in each instance by a feeling of numbness over the entire right side, a few hours before the attack.

In January, 1921, the attacks occurred every week, milder in degree, but similar in nature to the more severe convulsions. In February, 1921, a particularly severe convulsion was followed by a temporary inability to use his right leg. After this the right leg became stiff so that he was unable to lift his heel off the floor. In April, 1921, after a seizure which involved the entire right side of his body, the right arm became weak and was followed by weakness of the hand so that he was unable to write well.

For six weeks before entrance into hospital, he noticed that he made many mistakes

in calculation. His memory was becoming rapidly poorer, and he found greater and greater difficulty in reading.

Neurological examination by Dr. W. G. Spiller at this time revealed "very little weakness in the right side of his face. The right upper limb is a little weak. The right lower limb is distinctly weak, especially the foot. The right biceps and triceps reflexes are a little prompter than the left. The right patellar and Achilles reflexes are distinctly prompter than the left and there is distinct right ankle clonus and right Babinski. The sense of position is unquestionably impaired in the right hand and right toes. He has a distinct adiadokocinesis in the right hand. He has beginning word blindness and word deafness." It was Doctor Spiller's belief that "he probably has a tumor irritating especially the left centre for the lower limb but also the centre for the upper limb, implicating the parietal lobe and causing possibly, by pressure, slight implication of the left angular gyrus and left first temporal convolutions."

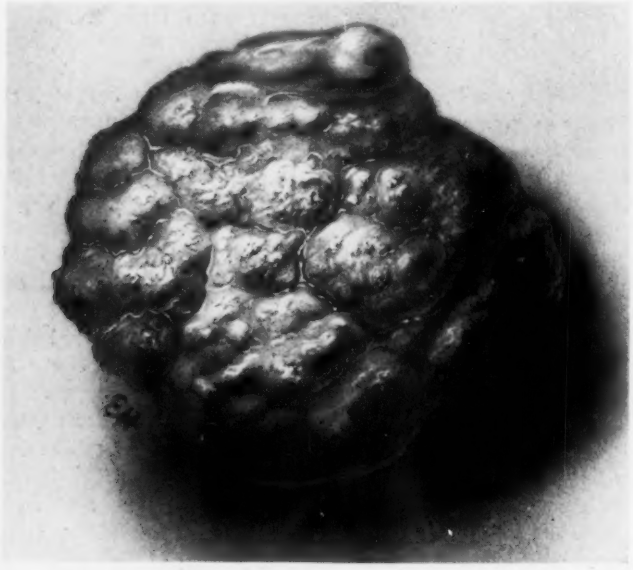

FIG. 1.—A drawing of the original tumor removed in 1931. Note the calcium on the superior surface and the complete encapsulation.

Special Studies.—The spinal-fluid pressure was seven millimetres of mercury. There was no evidence of papillœdema and no visual field disturbance. X-ray of the skull revealed a calcified tumor of the left parietal region.

Operation.—June 3, 1921, Doctor Frazier performed a left temporoparietal craniotomy. The bone was unusually thick, especially in the temporal region. A hard, fixed, irregular tumor was found adherent to the falx. It was sharply defined and easily separated from the surrounding hemisphere. "The point of origin of the growth, or at least the point of greatest attachment, was an area two to three centimetres long and one centimetre wide along the falx at the level of the longitudinal sinus." The tumor was cleanly removed. (Fig. 1.) Pathological study at this time showed that the tumor was an osteochondroma.

Course.—The patient left the hospital about four weeks after operation, very much improved. He was able to return to work in October, 1921, having recovered complete use of his right arm. The right leg still felt as if it did not have as much life as its fellow. In August, 1922, he experienced a jerking of this right leg but was well after this until April, 1925, when he was awakened by several convulsive twitchings

of this leg. For some time previous to this he had noticed a progressive weakness of the right leg.

Second Admission.—In April, 1928, the patient reëntered the hospital where examination by Dr. W. G. Spiller disclosed no disturbance whatever in the upper limb, whereas the right lower limb was much weaker than the left. Both patellar reflexes were exaggerated, the right more than the left, and the right Achilles reflex was likewise exaggerated. All sensation was normal. There was still no papillœdema nor visual field pathology. X-ray studies revealed a large calcified tumor in the left parietal region somewhat anterior to the original lesion. (Fig. 2.)

Operation.—May 19, 1928, the bone flap was again elevated, and May 19, 1925, Doctor Frazier again removed the tumor *in toto*. "It was in its dimensions and appearance almost precisely the same as that removed three and a half years previously." (Fig. 2.) Pathological study at this time led to a diagnosis of chondrosarcoma because of the

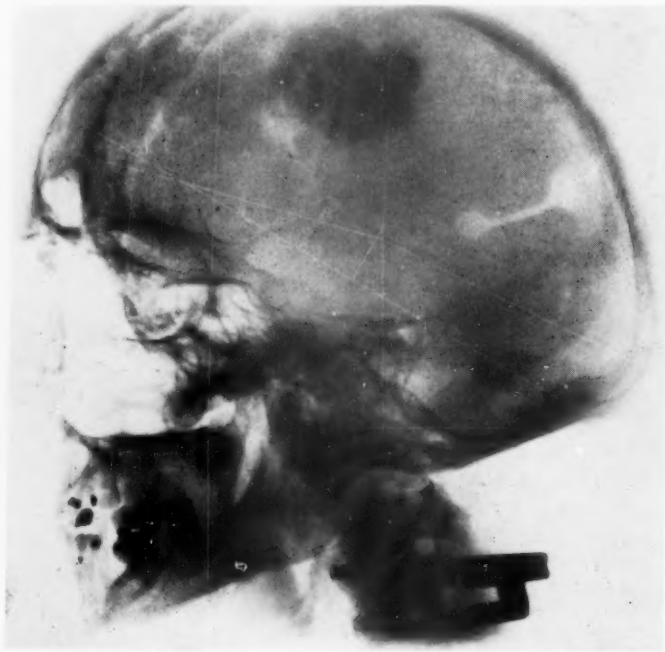

FIG. 2.—A photograph of a skull X-ray after operation, showing the calcified mass in the left parietal region.

presence of soft tissue among the cartilaginous elements, the prevailing cells being of the spindle type.

Course.—The patient was able to move his arm and leg quite well on discharge in June, 1925. He regained considerable power in his arm and leg. He received four courses of X-ray irradiation from June, 1925, to June, 1926.

Third Admission.—In September, 1925, he reëntered the hospital for irradiation therapy. At this time he was very well and was walking with the use of a cane, which he hardly needed.

Fourth Admission.—In November, 1925, he again entered the hospital, having continued to show great improvement. He still used a cane, but scarcely needed it. The right leg was weak and spastic, the right patellar reflex was exaggerated and he had a right-sided Babinski. X-ray studies at this time revealed a small calcification in the vault. He was treated by irradiation and discharged.

Fifth Admission.—In June, 1926, he again received irradiation therapy. There was no change in his condition at this time.

Sixth Admission.—In January, 1927, about six years after his first operation, he reëntered the hospital where neurological examination revealed a slight weakness of the right hand, weakness of the right leg, an increased right patellar reflex, and a right ankle clonus and Babinski. X-ray studies revealed a recurrence of the tumor.

Operation was again performed in January, 1927, by Doctor Frazier. The dura was found thickened everywhere around the tumor, and the falx was involved for four to five centimetres along the longitudinal sinus. The patient did not survive the operation and died eleven days afterward.

Pathology.—The pathological diagnosis in 1921 was osteochondroma, and in 1925 was chondrosarcoma. A histological study of both the 1921 and the 1925 specimens was made.

Fortunately, there were excellently preserved blocks of the original specimen and

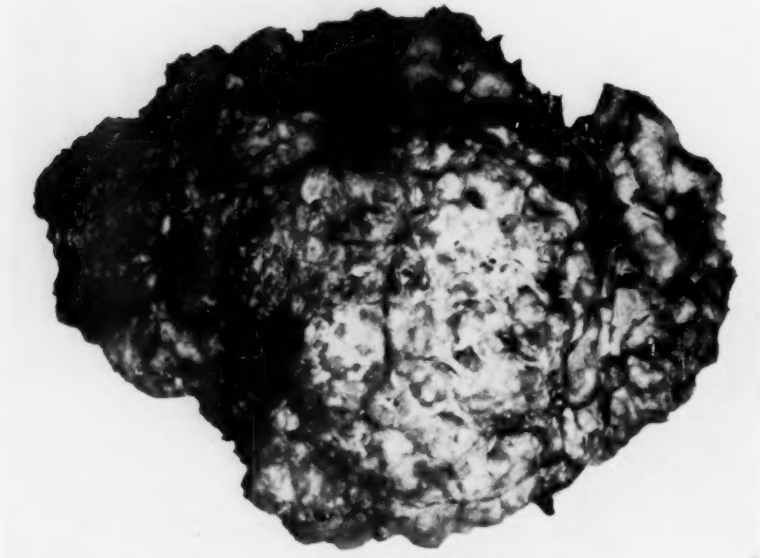

FIG. 3.—A photograph of the encapsulated tumor removed at the second operation in 1928.

from these were obtained very good sections. These showed a typical cartilaginous structure with portions of cartilage among which were rather extensive areas of soft tissue. The latter were composed chiefly of fibroblasts, among which were numerous blood-vessels. Definite transitions could be traced easily from these fibroblasts to the cartilage, the cells changing from bipolar to stellate and eventually to typical cartilage cells. A direct connection between these fibroblasts and the contiguous cartilage masses was visible. Other portions showed bone formation with osteoblasts on the edge of the bone spicules in which lay typical bone cells within a bony matrix. Transitions from fibroblasts to osteoblasts were readily seen. Not infrequently one encountered bony changes within the cartilaginous areas, the bone developing apparently directly within the cartilage. The section was a typical osteochondroma.

The specimen removed in 1925 was somewhat different in appearance. One section was composed of dura which was very much thickened. It had a portion which seemed to be of the usual thickness. Beneath this were what appeared to be many strands of fibrous tissue which looked as if they were formed by pulling apart the

dura. In this portion were numerous cells, among which were thin-walled blood channels. The cells contained a small round and lobulated nucleus which was very pyknotic. Small granules of calcium were seen here and there. No tissue comparable to the tumor was seen anywhere.

The tumor itself was encapsulated but the capsule did not extend entirely around the specimen. The capsule was composed of a dense fibrous structure with typical thinned-out fibroblasts lying parallel to the fibrous bands of tissue. Under this capsule here and there in the tumor, one saw a loose tissue, which when seen in the optimum areas, showed a transition to the cartilage in the tumor. These more loosely arranged cellular portions were composed of various types of cells. Next to the fibrous capsules were cells which still had thin spindle-shaped nuclei and a cytoplasm which was a little more extensive. A few small, thin prolongments could be seen emanating out from the cytoplasm. Beneath these, one found cells with plump oval nuclei containing a good nucleolus and scattered chromatin granules. They were vesicular. Thin

FIG. 4.—An area of cartilage from the tumor with portions of soft tissue adjacent to which are transitions to the more mature cartilage cells. H. and E. stain.

FIG. 5.—An area of cartilage with a piece of tumor capsule from which there appears to be some appositional cartilage growth. H. and E. stain.

cytoplasm was abundant. It was spread out around the nucleus and contained numerous thin prolongments which seemed to connect with those of other cells. They lay in a loose fibrillar carpet composed of fine fibrils. These cells spread over to others which were directly connected with the cartilaginous masses seen in the tumor.

Other soft portions of the tumor showed these transitions only vaguely. These were composed largely of spindle-shaped elements which were closely packed and which lay in a rather dense fibrillar carpet. They spread out here and there to show some of the transition forms already described.

Most of the tumor was composed of cartilage which contained cells lying in typical lacunæ. The cells were similar to those seen on the edge of the cartilage masses, with large vesicular nuclei and an abundant cytoplasm with indefinite prolongations. Most of the cartilage stained heavily and was calcified. Some portions were younger than others, taking only a mild eosin stain. In these portions calcification had not yet occurred. Here and there the cartilage masses were seen to be surrounded by the soft

loose tissue found near the capsule. No bone was seen in the tumor, but much of the cartilage was calcified.

The histological appearance of both specimens was that of a typical osteochondroma, the first specimen (1921) being the more typical. In the second the proliferative changes were more evident, the soft tissue portions being apparently more abundant than in the original tumor.

A case, similar to the one recorded, has been reported by Platou.[1] This tumor, the size of a goose egg, took its origin from the inside of the dura at its transition to the falx, and was found to be an osteochondroma. It was thought to be due to a "fetal factor." One of the first cases reported was that of Firket,[2] who found a chondroma growing from the inner layer of the dura and compressing the second frontal convolution. Brutt[3] found a chondroma also in a woman of twenty-one who had suffered with epilepsy for four years, with a few episodes of status epilepticus. There were spur-like shadows seen in the X-ray in the left parietal region. A large tumor was found in this region at operation adherent to the falx and extending to the base of the skull. The tumor was adherent to the parietal bone and seemed anchored there. The tumor, a large, cauliflower-like growth, was a chondroma histologically. Brutt decided that it took its origin from the dura forming the endosteum of the skull. In Smitt's[4] case, a chondroma was found in the left parietal region. While the tumor itself cast no shadow in this instance, there was an endostosis of the overlying skull. The tumor was adherent to the dura which was in turn very adherent to the skull. The tumor, which weighed 128 Gm., was round, opalescent, lobulated, and elastic in consistency. Histologically, it was composed of pure hyaline cartilage with other portions which consisted of soft fibrous tissue corresponding to the perichondrium. The endostosis was composed of typical bone structure without tumor-cells within the haversian systems. A large chondroma which was adherent to the anterior part of the falx and dura in the left fronto-parietal region was found by Froment, Wertheimer and Dechaume.[5] This tumor was seen by X-ray, shadows being present along the upper border of the falx cerebri. It was composed of typical hyaline cartilage. Another chondroma adherent to the falx was found by Verbrugghen and Learmonth.[6] This tumor compressed the cortical leg centre. Histologically, it was composed of cartilage tissue. The case of Guillain, Petit-Dutaillis, Bertrand and Schmite[7] was adherent to the dura of the right parieto-occipital region and was a typical chondroma histologically.

Not all the cerebral chondromas, however, are found over the convexities. Sometimes they are found at the base of the skull, especially in relation to the sphenoid bone. These differ probably from the chondromas of dural origin because of their bony attachment. Two chondromas in the ventricles have been reported by Letterer.[8] One of these tumors was situated in the third ventricle, where it was attached to the folds of the tela chorioidea. The other was in the right lateral ventricle. Their presence in these unusual places makes necessary some theory of their origin. Letterer asserts that a

TABLE I

Reported Cases of Cerebral Chondroma

Author	Age	Tumor Type	Location	Attachment	X-ray	Skull
Firket (1881)	?	Chondroma	Frontal	Dura	No shadow	No involvement
Smitt (1929)	29	Chondroma	Parietal	Dura	Endostosis in left parietal area	Endostosis. No invasion by tumor-cells
Guillain, Petit-Dutaillis, Bertrand, I, Schmite, P. (1930)	23	Chondroma	Parieto-occipital	Dura	No shadow	No involvement
Brutt (1931)	21	Chondroma	Parietal	Dura	Spur-like shadows in left parietal area	Tumor attached to bone
Verbrugghen and Learmonth (1932)	39	Chondroma	Precentral	Falx	None	No involvement
Froment, Wertheimer, Dechaume (1932)	37	Chondroma	Frontoparietal	Falx and dura	Shadows along anterior superior border of falx	No involvement
Platou (1933)	?	Osteochondroma	Frontal	Falx	Shadow in frontal area	No involvement
Alpers (1934)	49	Osteochondroma	Precentral and parietal	Falx	Shadow in parietal area	No involvement

metaplasia from fibroblastic tissue does not explain the occurrence of these chondromas in the ventricles for the reason that in all the reported instances of chondroma, there are transitions between connective tissue and cartilage and even bone. Because evidence of this is lacking in his case he does not accept their metaplastic origin, but asserts rather that they are due to embryonic rests. He derives the third ventricle tumor from rests of cartilage or pre-cartilage celis because in an embryo of ten weeks he found cartilage-like cells in the mesenchyme above the choroid plexus anlage. He believes the tumor in the lateral ventricle is derived from heteroplastically developed cells of the dura.

Only eight cases of chondroma over the cerebral hemispheres have been recorded. (Table I.) Five of these were pure chondromas, while two, those of Platou and Alpers, were osteochondromas. Despite this, two of the pure

chondromas showed shadows by X-ray. In these cases there were small calcified or bony areas, while in the cases of Platou and Alpers, almost the entire tumor was outlined by X-ray. In one instance, that of Smitt, there was an endostosis of the overlying skull. This was composed of bone histologically but was not invaded by tumor cells. In Brutt's case the tumor was anchored in part to the bone, but no mention was made of the presence or absence of bone invasion by the tumor. In five of the cases the tumor was in the parietal region, in two it was frontal, and in one precentral.

The cerebral chondromas are encapsulated tumors with a firm dural attachment. All the recorded instances have been attached to the dura (four cases) or to the falx (four cases). Sometimes the dura is very firmly attached to the skull so that it can be detached only with great difficulty.

FIG. 6.—A portion of tumor composed mainly of soft tissue with contiguous areas of cartilage in various stages of development from the fibroblastic tissue. H. and E. stain.

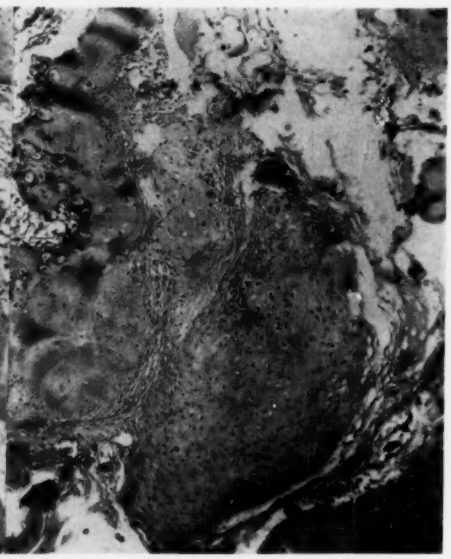

FIG. 7.—Transition from the soft fibroblastic tissue to cartilage is clearly seen. H. and E. stain.

Like the other encapsulated tumors of the cerebrum, the chondromas compress the brain and imbed themselves within it, but they do not invade it. Unless the dural attachment is removed with the tumor, the chondromas tend to recur (Alpers). Histologically, the tumors recorded have been true chondromas with perichondrial-like tissue which serves as the centres of growth. In the cases of Platou and Alpers the tumors were greatly calcified, and in the case of Alpers there were small islands of bone formation with true bone-cells within the tumor. These two cases are the only recorded instances of osteochondroma. Histologically, the chondromas in the cerebrum differ in no way from those in other parts of the body. They possess a thin capsule, relatively few blood-vessels, much hyaline cartilage, and a varying

amount of soft tissue. They are benign, but as indicated, unless the dural attachment is removed they tend to recur.

Discussion.—It is essential that we correlate, if possible, the rarer types of encapsulated tumors in the cranial cavity with our knowledge of the encapsulated cerebral tumors in general, in order that there may be further clarification of this still complicated problem. If this correlation is not possible, the description and recording of the less common tumors related to the meninges is still an important assignment for, if in so doing, it is demonstrated that there are tumor types which are not derived from fibroblasts, the problem of the encapsulated cerebral tumors becomes better defined despite its increased complexity.

The tumor which we have described was extracerebral, and was the only

FIG. 8.—An area similar to that in the preceding figure. H. and E. stain.

tumor of this type in Doctor Frazier's series. It was firmly attached to the falx and in part also to the dura. Its greatest attachment was to the falx. It was encapsulated, at no time exhibiting any evidence of infiltration of the brain tissue. Histologically, it exhibited the typical characteristics of an osteochondroma.

The encapsulated tumors of the cerebral hemispheres which usually have a dural attachment and are sometimes accompanied by hyperostoses of the overlying cranial bones, take their origin from the fibroblasts which line the under surface of the dura and the arachnoid. These tumors are composed primarily of fibroblasts. By virtue of the fact that there may be much variation in the degree of differentiation of the fibroblast products, these tumors differ quite considerably in their appearance, some containing fewer interstitial products, some more. Calcium is sometimes found in the tumors,

and rarely bone is seen. Whether this is produced by the fibroblasts is not clear. Cartilage being a product of fibroblastic differentiation, it is not altogether surprising that a tumor of cartilaginous structure such as ours is found in intimate relation to the dura. In the histogenesis of cartilage from the undifferentiated mesenchyme, fibroblasts play an important rôle, especially in the oppositional growth of cartilage. During its development the transformation of fibroblasts into cartilage cells has been frequently observed. It seems reasonable to assume that in the case of a tumor such as the one described here, fibroblasts were activated to produce cartilage cells. It is known that in the production of meningeal fibroblastomas, the meningeal fibroblasts may exhibit various degrees of differentiation, with a subsequent variation in the degree of maturity of the tumor as judged by the presence of cellular products such as collagen, fibroglia, and reticulin. It is conceivable that in the tumor which we are recording, the meningeal fibroblasts developed to only a very immature stage, from which differentiation into cartilage cells was not a difficult task. What this stimulus was for the production of cartilage and why it does not occur more frequently, is difficult to say. There is no available answer to this at the present time.

Similar activity on the part of the meningeal fibroblasts is found in the presence of calcium and bone deposit in the meninges, especially in older individuals. In the falx particularly deposits of bone may be found. These are usually found as irregular flat deposits of hard tissue of bony consistency, wrapped apparently in folds of dura within the falx. Their size varies but they are usually the size of small almonds. Sometimes they form confluent masses which are connected by small bony bridges. Microscopically, they possess true bone structure. A study of these areas reveals that they are in intimate relation to the dura in which they lie and that they are derived from fibroblasts. In one case which I studied, a definite connection between the outer layer of flattened cells around one of these accumulations and the dura was plainly evident, the dural tissue thinning out apparently to send a thin sheet around the bony tissue. While no direct connection between the flat cells at the edge of the bone and those of the dura was evident, the rather intimate association is very suggestive.

It seems clear that with advancing age, deposits of bone are found within the dura and that these are probably connected with the fibroblasts lining the dural envelope. The same membrane which gives origin at times to bony deposits may also upon very rare occasions give rise to cartilage as seen in our case, both these tissues being of fibroblastic origin.

Furthermore, the deposit of bone may be assumed by the fibroblasts within a fibroblastoma as seen in the cases of Weiser[9] and Berner.[10] The question naturally arises whether our tumor was originally a fibroblastoma, and whether the bony changes did not arise secondarily within such a tumor. The bony and cartilage deposits were primary, there being no evidence of fibroblastomatous structure in the specimen. The histology, moreover, was

that of an osteochondroma rather than a fibroblastoma. Finally, the recurrences of the tumor were always calcified and appeared so in the X-ray.

There is good evidence, therefore, that the fibroblasts of the arachnoid are capable of producing both cartilage and bone. Apparently also, judging by the cases of Letterer, similar cells in the choroid plexus are capable of assuming cartilage-forming functions. The cartilaginous tumors derived from the arachnoidal fibroblasts are therefore related to the meningeal fibroblastomas from the point of view of their origin though structurally they are quite different tumors.

CONCLUSIONS

(1) A case of recurring cerebral osteochondroma is reported.

(2) The tumor was attached to the falx cerebri and partly also from the dura over the hemisphere.

(3) The tumor probably took its origin from meningeal fibroblasts.

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DEAFNESS AS A PSYCHOLOGICAL ENTITY

By Gordon Berry, M.D.
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Progressive deafness is not solely a chronic catarrhal process, with perhaps some otosclerosis superimposed and even an atrophy of certain cochlear end-organs. This is the physical malady which can be tested and examined, discussed, treated and labored with. There is still another phase which the learned diagnostician cannot demonstrate through his otoscope or by his audiogram or in his microscopical slide. It is to bring to your attention this aspect, that one of the host of the afflicted takes the liberty of entering your ken, as a composite individual, if you will, to tell you of this thing called deafness. He invites you to step through the looking-glass as you did with Alice-in-Wonderland and join him in examining colors and forms that cannot be seen on the membrana tympani or on a pathological section of the basillar membrane.

Would that there were time to journey through the schools for the deaf. Here, quietly and diligently, is being written one of the finest and most heroic chapters that will ever appear in the story of education. Rather let us first visit the third-grade classroom in a public school. Tommy is a bright-looking little lad. He seems eager, anxious to please his teacher. A simple question is asked. He should know the answer but gives an erroneous one. The teacher chides. Tommy looks surprised and confused. We who are behind the scenes know that Tommy did not hear the question correctly and thought he gave the right answer.

Now step into the fourth-grade room across the hall. Here we find Mary who is harder of hearing than Tommy. But neither the teacher nor Mary know this. The child is nervous, twitching, thin, has an anxious, searching expression. Her keen eyes shift quickly about the room. She is blinded a little by the window just beyond the teacher's face but by intense scrutiny she reads the teacher's lips successfully, as she has unconsciously learned to read her mother's lips at home. We inquire how Mary is doing in her work. The teacher says she is somewhat backward and apparently stupid but has thus far just managed to keep up with the children of the same age. The teacher wonders whether she ought to take her for an intelligence test. A lovely child, she says, but cries fairly easily, and does not like to go out and play at recess.

Mary is so different from her brother Jack who is four years older but in the same grade. Teacher is quite sure that Jack's hearing is impaired. His most frequent answer is "I don't know" and his marks are consequently bad. Jack, it appears, is a mischief-maker. At recess he bullies his much smaller classmates. He is physically strong and gets into fights and even seems to

enjoy them. He lies fairly easily, and was caught in a petty thievery two weeks ago.

One more illustration will suffice. This is Annie. She is fourteen years old and struggling gallantly to keep up with her classmates who are two years younger. She knows she is "just a little deaf" and so does her teacher, but she cannot understand why she makes so many errors, and why her friends whisper in groups and never talk loud enough for her to hear. She wants to be happy and gay and have loving friends around her, but she is finding it simpler to play by herself. She loves her doll and makes pretty dresses for it and then takes it to bed with her and sobs herself to sleep.

To us who are granted this understanding vision, these hard-of-hearing children appear in their true light as warped and twisted from the normal jolly children they should be. These mistakes they have made and these hardships they have endured are not occasional but daily occurrences. There is none to explain. The child cannot understand; nor does the teacher; nor the parent. How important that audiometric tests be made throughout our school systems and that these advancing cases be found and understood early. A sympathetic and coöperative teacher, a protecting and guiding parent, a skilled and helping doctor and what a difference on the child's education, on his development, on his ultimate place in the community. It costs the city sixty to eighty dollars to teach a child a half-year. Some of these unfortunates drop back four and even six times. And the three hundred dollars wasted is not so important as the wasted years and the twisted personality and the sense of being an economic and social misfit. Here are made some of our dependents and paupers on the one hand and our delinquents and criminals on the other.

Perhaps the child has gone through trade school or college and has begun his life's work before the hearing impairment begins. This young adult looks forward with zest to a full and useful life only to discover that an encroaching deafness makes difficult or impossible the trade or profession for which he is prepared. Progressive deafness usually starts in early adult life and becomes a definite handicap in the twenties, just as the long training period has been completed and social and economic responsibilities are being assumed. What does our young man do when deafness stalks near?

From an economic standpoint, he must review his assets in terms of training, natural skill, personality, perseverance, thoroughness and judgment, balance them against the known liability of increasing deafness, and ascertain the result. There are certain trades and vocations where the acoustic sense is an important factor. A telephone operator, an expert automobile technician, a specialist in chest diseases, a trial lawyer, a minister, would find a considerable deafness an almost insurmountable handicap, and a change would seem imperative. But an outstanding trial lawyer in the South is extremely deaf, and so are two nationally known preachers of the writer's acquaintance. On the other hand there are many noisy trades where deafness, rather than offering a handicap, would prove a blessing. Oscar M. Sullivan, the Minnesota

State Director of the Re-education of Disabled Persons, says: "The most interesting thing that employment studies have shown so far, the most helpful thing, is the wide range of opportunities, the greater number of things that can be done by the handicapped of all types, and the great variation in personalities."

What are this young man's psychological reactions? Dr. Thomas L. Fentress informs us that if he is an extrovert "delighting in the society of his fellows and the activities of the external world, he is confronted with a serious problem, for he is unable to accept the natural and easy way of withdrawing into his shell, as the approval of his environment is essential to his peace of mind." Such a man tends to become seriously depressed and, rarely, to end his own life, or he may develop an irritable, discourteous bearing as an over-compensation, as Dr. Samuel Johnson did in later life. To the introvert, partial deafness is less trying. He already prefers to occupy himself with his inner life, and a further withdrawal from the society of others is the natural consequence. This presents its obvious hazard.

In the prime of life, the woman takes this burden harder than the man. The latter has made adjustments. Others are at hand to do his hearing for him or his daily office visitors have learned to raise their voices. He has perhaps become a member of a coöperating group and his day is filled with work and responsibilities where acute hearing is not essential. He is happy in his busy life and the opportunities for self-expression and community service, and on returning home finds further contentment in a good book and a comfortable easy chair and his pipe. The woman's life, unless she is in business, is made up of broader and more superficial contacts. Her friends will not adjust their voices and their social groupings to her; she must make the adjustments. And rough and steep will be her road as she climbs to peace and contentment.

As declining years come on, a senile type of deafness may supervene. And he who has run a good course and kept the faith finds himself faltering ere the race is run. Serene and deep must be the faith that can carry this added burden and come smiling through. But many there are who can triumphantly say:

> "It matters not how straight the gate
> How charged with punishment the scroll."

Intrinsically an encroaching deafness urges deception, and retirement. It is axiomatic that man desires to be perfect and that in seeking the commendation of his fellows, he wishes to belittle or hide any infirmity. This is both natural and commendable. As deafness increases, many of us will try to hide it. We will hear some of a sentence and guess the rest and frequently be successful. Perhaps we have been able to avoid interrupting the conversation, that we may be enlightened on what has been said. But we err frequently and lose track and our replies are either ridiculous and funny or inapt and irrelevant. Others in the group glance at each other and share

some opinion about our mistakes which we do not know. We have blundered. We are embarrassed. We seem stupid. We become confused and hesitant. What wonder that we not only try to deceive ourselves and our friends about our deafness but that we gradually assume an inferiority complex? We rate ourselves as under par and assure ourselves that others bear with us out of the goodness of their hearts and not because they desire our company. By necessity or desire we drop one activity and then another and our circle of friends and of activities becomes more and more constricted. It was Horace Howard Furness, the great Shakespearean scholar, who wrote declining an invitation to dine: "Thanks, more than would fill this sheet, for your hospitable intentions, but it is many years since I formed the resolution to sit at no table but my own. I am so deaf that I must either wholly listen, or wholly eat, and the attempt to divide the two always causes embarrassment to my host and to me; and since nature has instructed me to remain in the background, I take the hint and obey her request."

Other reactions become apparent. Acoustic memory may become somewhat atrophied. Names are grasped and retained better if learned through visual than through hearing channels. A hard-of-hearing person hesitates to form an opinion on spoken testimony because he has learned that what he hears is not always trustworthy. He is more sure if he sees or reads the evidence. As a medium of self-expression, there is an increasing preference for the written word.

The lighter phases and pleasing trivialities are not for the hard of hearing. They do not seem important, and neither the friend nor the handicapped listener wishes to go to such trouble as the needed exchange of pleasing gossip entails. So the art of light conversation atrophies unless the hard-of-hearing individual is one of those rare persons who both reads widely and converses brilliantly, in which case he may monopolize the conversation to the delight of all his hearers. It will be a one-sided conversation, however.

Is this then the entire picture? Is there no bright side? Read with me Margaret Prescott Montague's article entitled "The Lucky Lady" in last September's *Atlantic Monthly*, and learn how she sings hosanna because she lives in this modern age when so many helps are available to minimize her hearing handicap. Review the stories of the immortals who greatly served their race and time in spite of some physical disability. For many the infirmity was the obstacle whose surmounting gave them courage for greater deeds; and ultimate success may be said to have been because of their infirmity, not in spite of it. Perhaps the greatest orator of all time spoke with so slurred a tongue that he was with difficulty understood. We are told that he went down to the seashore and placing a pebble in his mouth tried to shout above the noise of the pounding waves. Here was fashioned the silver-tongued Demosthenes who later swayed the Athenian mob. Lord Byron, the cripple, finally swam the Hellespont; and our own President Roosevelt fought his way back to his present tireless health by a similar means. Charles Proteus Steinmetz and William Wilberforce were stunted

in body but the one harnessed the thunderbolt for mankind's comfort and delight and the other, nigh single-handed, freed the slaves throughout all the British Empire. On his tomb in Westminster Abbey a grateful nation placed the inscription, "The Attorney-General for the Friendless and the Unprotected." Did John Milton's physical blindness permit him to see more clearly the wondrous visions in "Paradise Lost"? The deaf Beethoven heard celestial symphonies which have blessed and satisfied a music-hungry world.

Among the hard of hearing there are many possible adjustments. Nature compensates richly if given a chance. The northern animal grows a thicker fur, the bear with his weak sight develops a marvelous sense of smell, a blind Helen Keller has a sense of touch which is beyond our comprehension, deaf children learn to read the lips with uncanny accuracy. Also, modern invention has made great strides in the efficiency and adaptability of ear-phones. These and the art of lip-reading are making it possible for most to surmount their handicap to a considerable degree.

The final adjustment and the most difficult seems to be the psychological one. The individual may be self-centred, timid and sensitive; or be selfish, suspicious, jealous, easily offended, arrogant. If adjusted, he can be happy, generous, sympathetic, helpful. Suffer he must but it need not warp his character or make him at odds with his neighbor.

In the business world deafness may be considered an asset in three ways: (a) It decreases distractions and increases concentration. "My nerves are stronger and better today than they would have been had my hearing been normal," wrote Thomas Edison. (b) It fosters constructive thought. Doctor Furness whose deafness compelled him to abandon the law and led to his exhaustive work on the New Variorum Shakespeare said it was his deafness which saved him from distractions and gave him his concentrated power of work. (c) It can increase the interpretive capacity of the other senses. This is in accordance with nature's law of compensations.

In social life deafness encourages only intimate friends who know and understand and value the companionship. In the spiritual realm, deafness urges that more time be spent in thought and that less be frittered away by the movies and the radio. It spares one the jarring cacophonies of our modern jazzed-up world and permits him who will a quieter consideration of life's purposes. The great leaders of the world have gained their creative ideas and strength through solitude, says Frederick M. Duckles, "One does not need a hearing device to hear God's voice."

Throughout the country, leagues for the hard of hearing have been formed. They are proving remarkable agencies for bringing these despondent and timid individuals back into a normal attitude toward life. There are now 130 of these leagues in the United States and eight in Canada. Most of them have united under the leadership of the American Federation of Organizations for the Hard of Hearing. The membership approximates nine thousand. Through these agencies a leaven is working to change the

attitude of those who heretofore have been increasingly retiring from active community life. Mrs. Johnson used to spend her days in self-pity but now she is so busy thinking and planning for others that there is no time nor desire for introspection. Each of us wishes to express himself, enjoy the commendation of his fellows. So does Mrs. Johnson who now plays bridge at the League, joins the lip-reading class, listens to a travel-talk over the group ear-phone, helps an unemployed fellow-sufferer secure a job, lends a helping hand wherever she can; in short, expresses herself, enjoys her life and cheers her neighbor. What a difference!

The task is not a simple one. Adjustments are difficult. Set-backs and discouragements are numerous. But success does await "him who overcometh." In an effort to epitomize these processes of change and adjustment, nine brief rules have been assembled for these hard of hearing. They may perchance help others over some of the bumps and bring to them greater courage and happiness. They will serve as a closing summary.

"THE NINE COMMANDMENTS FOR THE HARD OF HEARING"

I. Thou shalt frankly confess thy deafness to thyself and before thy fellow men. Let there be no deceit nor false pride.

II. Thou shalt not covet thy neighbors hearing but shalt rejoice that thou livest in an age when thy handicap can be made so small.

III. Early and again shalt thou consult thy otologist and accept every scientific aid he can render.

IV. Eschew the quack and his devices. Easy and broad is the way to his door and many there be that find it.

V. Thou shalt join and work for a league for the hard of hearing where thou wilt receive encouragement and stimulation for thyself and wilt find happiness in serving thy brother. Thus wilt thou march forward with the Federation army that is alleviating deafness throughout the world.

VI. So love thy neighbor that thou do everything in thy power to help him when he would have speech with thee. To this end:

VII. Thou shalt study lip-reading, in season and out of season.

VIII. Thou shalt secure and use the best ear-phone thou canst discover.

IX. Triumphantly shalt thou rise above thine infirmity; and so conduct thy life that the world hath need of thee.

POST-ENCEPHALITIC PERSONALITY DISORDERS

THEIR NATURE AND TREATMENT

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From the Institute of the Pennsylvania Hospital

Encephalitis is a disease whose physical manifestations are well known. The parkinsonian syndrome is a distressing condition that sometimes follows the acute disease. The character changes or personality disorders that sometimes follow encephalitis in children are less well appreciated. In this article we should like to call attention to certain aspects of encephalitis in children which are often overlooked, present the essentials of a plan of treatment that has been found workable and satisfactory, and make a few suggestions as to how the State can save considerable distress and money, and help re-create some of its broken citizens.

In encephalitis the late stage may of course be expressed in terms of progressive paralysis with its need of medical treatment by drugs. But just as characteristically it may be expressed in terms of distressing but most important social mal-behavior. Such behavior is shown often in children of good intelligence who have become disobedient, untrainable at home and school, with lying, stealing, and repeated running away. Frequently they are mawkishly affectionate, and inordinately restless. This is the typical problem of post-encephalitic behavior which the community is called upon to solve.

Our experience with a hospital school which has treated about 100 of these cases, most of them in residence for a year or more, has been instructive.[1] Some symptoms besides the neurological ones can fairly be traced back to the organic lesion, the motor restlessness, the distractibility, the sudden emotional changes. Other symptoms seem due to the management of the convalescence from the acute illness, and for this there are many reasons. In the first place, in contrast to the situation in infantile paralysis, there is a situation either unknown and misunderstood, or recognized as an insidious, often progressive, and terrifyingly indefinite malady. Neither physician, patient nor family know where they stand. The family is irritated by the most tantalizing behavior in the world. The child sleeps when he ought to study, and stays awake all night rummaging the bureau drawers and desks; objects are injured; destroyed or burned with no consideration of their value; the child steals openly and gives what he steals indiscriminately to teachers, playmates or strangers; he runs away, curled up in the spare tire of an automobile or in a box car. The family naturally brings to bear punishment, which does not produce good results. Or in some cases, the family is told by the doctor never to cross the child. If brain disease is

suggested, parents naturally become indulgent. After some especially malicious behavior they may be reminded by the child himself that he should not be punished because he has had sleeping sickness.

How much of this post-encephalitic behavior is due to organic brain change and how much to unfortunate psychological training and discipline it is impossible to say. However, retraining and reëducation in a third of the cases, at least, bring about social recovery, and the child can return home and adjust satisfactorily.

CASE I.—Let us cite the story of two boys, one post-encephalitic, the other possibly encephalitic. The first, at the age of seven years, began a career of restlessness, tantrums, night wanderings, vicious attacks on other children, stealing and truancy which led him to the attention of thirteen charitable organizations and six schools. Brought to the hospital school for over two years, given a chance to talk out his very aggressive tendencies (he told remarkable phantasies of the use of guns in crime), surrounded by expert teachers, he seemed completely to adjust himself, finally attending public school from the hospital.

CASE II.—The second boy, classed as feebleminded, insane, sexually abnormal, and criminal, at the age of five years, was found by the Philadelphia Child Guidance Clinic to be responsive. He was placed in the hospital school, given frequent psychiatric interviews, with the net result that after one year he was found to be very bright (I.Q. 120), emotionally stable, and sexually and socially well-behaved. Layers of misunderstandings had been removed to show a normal person underneath the hopeless diagnosis.

In what follows we should like to report with more detail a concrete case illustrating the type of treatment that has helped formerly hopeless children to return to their homes and society.

CASE III.—Julia was twelve years old when she came to the school at the Pennsylvania Hospital in Philadelphia for post-encephalitic behavior disorders. She had had an instrumental birth but suffered no post-natal difficulties and her development was normal. There were no neurological residues. At three years she was in bed four weeks with the diagnosis of a severe case of influenza. In convalescence she had to be taught to walk again. She was fidgety and restless. The face muscles twitched and her eyes presented unusual movements. Marked temper displays appeared. This so-called nervousness persisted and on entering school at six years it increased She was teased for it. There was impulsive, apparently unmotivated, screaming. She was afraid in the dark, yet refused to come in from the street at night. Suggestions that she help in the home with any kind of housework were the occasion of tantrums. When reprimanded, she was vulgar and profane. Stealing was frequent and she lied with no conscience. With her playmates she was unpopular and quarrelsome. There had been numerous unfortunate sex experiences with boys. She was impossible at school and could not be handled at home.

At the hospital school she exhibited violent temper tantrums, kicked, bit, screamed. She threatened to kill children and nurses. She attacked others with vases, brooms, and kitchen utensils. Often she refused to talk and stared in space. In the classroom her work was poor, she was slow but responded to praise. Her intelligence quotient was low, giving her an intellectual in addition to an emotional handicap.

Conferences shared by all the people working with the children are a part of the routine at the school, in order to pool the impressions and suggestions of psychiatrists, psychologists, social workers, occupational teacher, school teacher, nurses, and athletic director. All agreed Julia had too much aggressiveness, self-confidence, and gregariousness. Her attitude toward facts was underdeveloped. She was too expressive, tried to have her own way too much, and was often a bully. She was extremely fond of com-

panionship. Over-enthusiastic, grievances hung on too long, lying was frequent, there were frequent mood swings and she was flighty. All this suggested that we use her self-confidence, her drive for affection, and need for companionship, to oppose her aggressive and dominating tendencies. If we found things that really interested her we felt we could help overcome flightiness. Understanding and control would help her exaggerated emotional swings and the tendency to hang on to grievances.

Other reports were that her school work was poor, that she resented criticism, informed on the other children, and lied. She was erotic and fearful. She had real interests in animals, cooking and housekeeping, outdoor games, and arts and crafts. At jobs she liked she would contentedly and reliably work all morning. Through the conference method her outstanding traits both favorable and unfavorable were brought into relief.

In discussing the best approach to her problem it was realized that it was obviously unwise to expect too much from our patient. She had definite mental limitations. Concrete things were better for her than abstract ones. It was felt that one of the reasons why she got into mischief when alone was because she was lacking in constructive initiative. This had to be supplied by the supervisors. We decided to give her praise and responsibility whenever it was possible. An appeal could be made to her to set an example because she was the oldest child. Isolation was advised for some difficulties. Because she had such a strong desire to be popular, reprimands in the presence of others were resented and produced tantrums. Private talks and reasoning with her, rather than public correction, were advised. These helped to establish confidence and coöperation. They showed the child we had personal interest in her. Finally it was felt Julia's overdeveloped aggressiveness, and attempts to domineer, were efforts to secure on a physical plane what she could not obtain with reasoning or intuition. It was our job to help make up for these deficiencies. Formulating a problem goes a great way in helping a child. It makes us think in terms of what we can do for the child rather than how we can train him. Service rather than mastery is the more helpful point of view for the child and more wholesome for the supervisors.

Things did not always go smoothly. At times there was great difficulty with eroticism. Reading de Schweinitz's "Growing Up" to the whole group helped tremendously, and the airing given sex, and the free and truthful answering of all sex questions in open conference took away much of the mystery and spell of these matters.

Continuous warm baths were necessary at times to relax Julia in her tantrums. Substitution of other activities or changing her interest often was helpful in the tantrums. The nurse discovered that due to her enormous appetite an excellent appeal could be made to her through her stomach in addition to intellectual appeals. Personal talks helped in appealing to her desire to be grown up. We tried to appeal to her conquering and domineering spirit in overcoming her difficulties.

As months passed, encouraging reports began to appear. But after three months in the hospital she was felt to be homicidal. We kept on trying to appeal to her and help her with our unexciting methods. Her antagonistic, emotional, and threatening reactions were met in a cool, friendly way, in contrast to what she had had at home and school. Her confidence was obtained and she coöperated in making reports on herself. Often, for example, she brought us reports about her threat to kill someone. An interest was aroused in this problem and after months this hostility spent itself and she used control. In the personal talks it was pointed out that her handwork was better than most children's and that she should not worry if she could excel in that and not in school. Encouragement and pointing out assets help children as well as adults. Her dramatic ability was excellent, and it was used to balance her limitations in other fields.

Julia's fears especially at night were very pronounced and difficult to deal with. We encouraged her to speak about them and never shamed her. She had had a background of fear. Her father had punished her severely with whippings. Her mother

had been severely burned, so that the child lived in a background of apprehension especially about fire. She had unusually vivid and morbid dreams. She often dreamt her mother had died or was a skeleton. One night she dreamt another child was taken to the woods and murdered by a man. Another night she dreamt a child was going to murder her with a big knife. The patient had been having difficulties with those children, they had broken something of hers and her revenge came out in dreams.

Ultimately our little patient did very well. Essentially she caught our spirit. She realized we were there to help her. After about a year she was ready to go home. She discussed her delinquencies with us with fairly good understanding. She knew she had been there to learn how to get along with people, to coöperate, be agreeable, and helpful. She had discovered that when she had learned to do these things she could go home, and she did. She softened immensely during her stay. Her aggressiveness no longer expressed itself in fighting and personal injury. A story she told me several days before leaving, while still manifesting morbid patterns of thinking, showed a tendency to acknowledge guilt. There was the confession of something terrible in the story. But the ending did not suggest the former spirit of revolt and revenge, but one of reconciliation. The story was as follows:

"A husband told his wife that he was going to put his son in the oven. He finally did, and then told the police to search for his son who was lost. The husband became sick and before he died he called a priest and told him of his terrible deed. The priest told him to tell the police, which he did. The police thought of doing the same thing to him (putting him in the oven) but they didn't." Whatever we may think of the theories of stories, phantasies, and dreams, certain things seem clear. There is something in each particular picture, whether dream or phantasy, which is interesting to the child, whether it is appealing or an object of fear. Somehow or other it fits into the mental picture. We might say the mind (of which we know only a part) selects these images out of countless other possibilities, because they belong or fit the total picture. A story like the one we have just quoted expresses notions of cruelty, accident (sickness), remorse, confession, revenge and reconciliation. It shows that the uncontrolled thinking of that child was playing with these images. We felt encouraged that there was remorse and confession, and that the story ended with a reconciliation, rather than with revenge. Aggressiveness, cruelty, and retaliation were characteristics of our patient on entry. These impulses had been wholesomely influenced by her stay in the hospital, and there was reconciliation established between her impulses and the desires of environment. In the hospital school she learned to make adjustment between herself and the social milieu in which she found herself, and it has been possible to transfer that adjustment to society at large.

We have sketched in brief an adventure in psychotherapy. It is the process of all genuine education. Social education, education of the individual to adjust to society and its customs, is the most important education. It takes the raw impulses of power and domination and transforms them in part into submission and deference. Possessiveness must be partially relinquished and become concession and surrender. Curiosity becomes restrained, and showing off must give place to some degree of modesty. Hate and antagonism must become love and coöperation, and so on. And this transformation of our aboriginal, savage nature cannot be made by emphasizing power, discipline, authority. It can be made by understanding, patience, sympathy and courage. Tyranny, punishment, anger, shame, threats or fear will not accomplish this. For these are the impulses that disorganize society itself and they certainly disrupt the individual personality. By treatment of

the sort we have sketched, a child who seemed destined to spend her life in an institution has become able to get along at home and become a reasonably coöperative member of society. The disease she suffered from released disruptive tendencies within her, drugs could not overcome them, but patient psychological training could reëstablish restraint and control.

Here, then, in encephalitis, are behavior situations with one origin in certain organic brain lesions and another origin in the ways in which the organic handicap is handled. The community's interest is obvious: these lesions occur in many gifted children whose talents should be saved; the tendencies to anti-social behavior are so great that the community should protect itself. The ordinary family cannot be expected to cope with these difficulties, to give either the physical or the mental care which is demanded. Doctor Healy states the post-encephalitic children are usually too much for a foster family. Correctional institutions only make matters worse. The community must come forward with hospitals and camps. To reëducate these children it should furnish highly trained teachers and social workers, special diagnostic centres, special schools with classes limited to fifteen pupils, with the right to exclude the feebleminded, and as a last resource it should maintain a boarding school under psychiatric auspices. This plan is difficult and expensive, but it is easier and less expensive than no plan at all. Care under such a community plan will prevent the disorganization of families and neighborhoods, will prevent the development of some criminals, will save many talented children, and will offer many suggestions for the better education of all difficult or unusual children.

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LINGUAL SPASM

By Stanley Cobb, M.D.,
and
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From the Neurological and Psychiatric Services of the Massachusetts General Hospital

The important work of Frazier and his collaborators on trigeminal neuralgia and its clinical variants has aroused among neurologists and neurosurgeons a widespread interest. In reviewing our cases of atypical trigeminal neuralgia, we found three who have been relieved temporarily of their pain by an operation on the gasserian ganglion, but who later have developed a spasmodic contracture of half of the tongue. We believe that this may be looked upon as a rare complication. In two of the cases it was merely an occasional inconvenience that, at times, made speech and swallowing difficult. The spasm was always on the side that had been operated upon. It usually came on with fatigue as in prolonged speaking, or with local irritation to the tongue during eating. In the third case it was more severe. In all cases there was an associated atypical facial neuralgia[1, 2, 3] that had developed after operative relief of the trigeminal neuralgia. The third case is herewith reported and discussed. It is of especial interest because an operation by Dr. Leroy M. S. Miner, in which he cut the atrophied lingual nerve, entirely cured the lingual spasm.

Case Report.—The patient was first seen in 1915, complaining of intermittent pain in the left side of her face. She was then thirty-two years old. She had lived a normal, healthy life, except for an attack of bursitis with neuritis of the right arm. This came on three months after a fall from her bicycle when she was thirteen years of age. At eighteen years Dr. E. W. Clap reports she had diplopia due to congenital amblyopia and insufficiency of convergence with slight right hyperphoria.

She came to us for pain in the left temporal and supra-orbital region. The pain was not typical of the usual form of trigeminal neuraligia in that the pain would come in waves lasting an hour or more. There was increased sensitivity to painful stimuli in the distribution of the first division of the fifth nerve on the left, but otherwise physical examination was not remarkable. The Wassermann was negative. After an unsuccessful alcohol injection the first division was cut in the eyebrow, which gave complete relief.

Two months later she began to complain of pain of the same character in her cheek and the upper jaw. On account of the atypical character of the pain and the fact that it was not relieved by alcohol injection, posterior root section was not advised and instead the infra-orbital nerve was divulsed. This gave relief but pain appeared in the lower jaw, and the third mandibular nerve was cut where it enters the jaw. Following these operations she was relieved of all pain except for slight twinges in the eyeball and remained so until the early part of 1922, when she began to have recurrence of pain in all three divisions associated with a good deal of spasmodic motor *tic* in the left side of her face. She was in good general condition except for some mucous colitis, and posterior root section was advised and performed. All the fibres within the sheath were sectioned, no attempt being made to preserve the motor root. Imme-

diately following this operation the facial (seventh) nerve functioned perfectly, but by the end of the first post-operative day she had developed a complete facial palsy of the peripheral type.

There was complete relief of pain following this operation, but the seventh nerve palsy was very troublesome. During the years that have passed she has regained a good deal of function in this nerve, though recovery has not been complete. Examination at that time (1922) showed absence of sensation in the skin of the face, diminution of tear secretion in the left eye, but preservation of deep sensation.

In 1924 there was a return of pain in the left side of the face, but it was different in character from the old neuralgia. It seemed to the patient to be deep in the malar bone, and sometimes in the maxilla and mandible. She noticed that exposure to cold, fatigue and nervous tension were precipitating factors. Household anxieties that caused her to become nervous would make the left side of her face feel stiff, and then the twinges of pain would begin, going on to a steady, deep burning pain. This condition continued to become gradually worse.

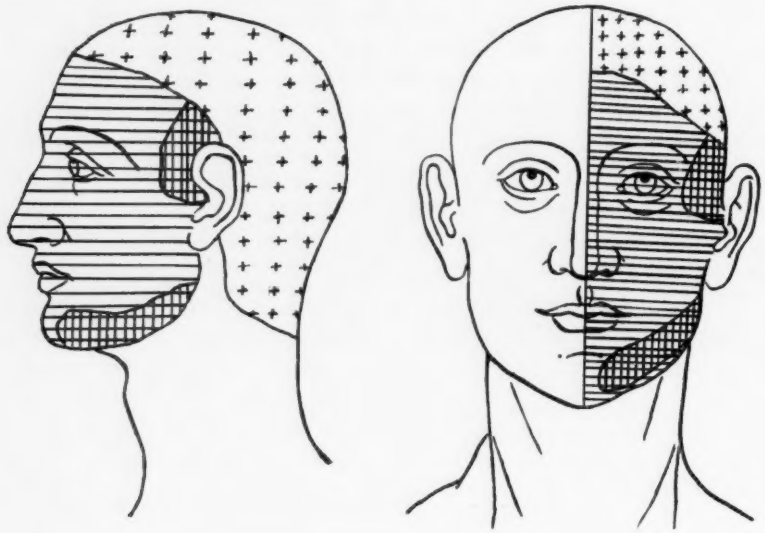

FIG. 1.— Tenderness and paræsthesia.

Slight hypo-æsthesia to prick but normal to brush.

Hypo-æsthesia to prick and to brush.

On August 17, 1925, a brief neurological examination showed:

Cranial Nerves.—I. Normal.

II. Vision is apparently good, but only the right eye is used because of the poor binocular vision and the use of vaseline in the left eye.

III, IV, and VI. The left eye tends to turn inward and, when she looks at an object held approximately three feet away, the image in the left eye is lower than, and to the right of the image of the right eye. This is practically permanent and is not helped by glasses.

V. On opening the mouth, the jaw is displaced to the left. There is practically normal perception of light touch over the whole of the area innervated by the left trigeminal;

pressure and pain are felt dully; localization is good (Fig. 1); right side normal. There is complete anæsthesia of the left half of the tongue.

VII. There is still a left facial weakness in all three divisions of the nerve, but this is less marked than two years ago; she can close her eye and move the left corner of her mouth much better.

VIII. There is continual buzzing and snapping in the left ear. On rough test, hearing appears to be perfectly good. There is staggering at times. She tends to bend her head towards the left shoulder.

IX, X, and XI. The left half of the palate appears to be weak on phonation;

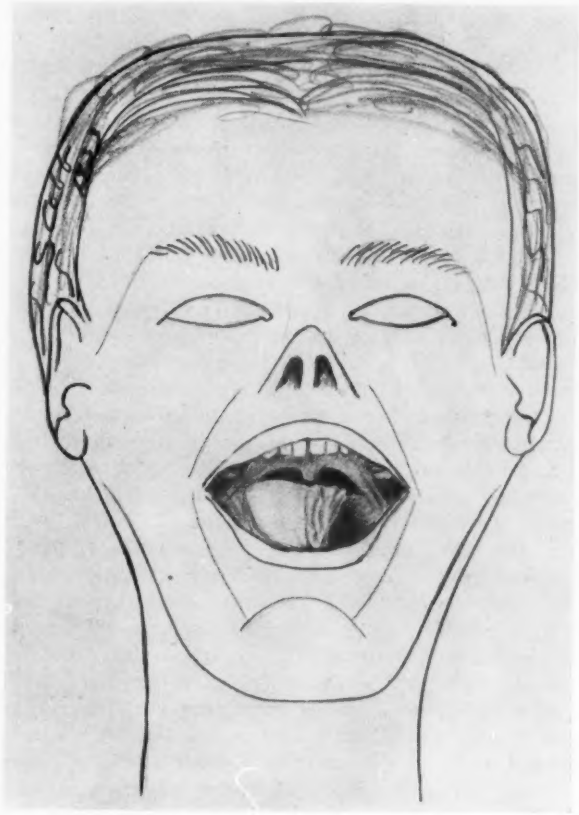

FIG. 2.—Spasm of the left half of the tongue. From a sketch made at bedside on April 12, 1929.

this left side hangs and lags behind the right. There is tenderness in the left external auditory meatus. Taste not tested.

XII. The tongue is protruded in the mid-line and shows no atrophy or weakness.

Sympathetic.—The left side of the face has very marked vasomotor reactions. Exposure to sunlight brings on marked flushing on this side, which stops exactly at the mid-line. The left eye and left nostril secrete on very slight provocation.

A complete neurological examination on November 13, 1925, substantiated the above findings. In addition it was observed that the right forearm was larger and stronger than the left. The deep reflexes of the arms were active and equal. The knee-jerks and ankle-jerks were hyperactive, possibly greater on the left. The plantar

reflex was normal on the right, on the left there was occasionally an equivocal Babinski's sign. The abdominal reflexes were decreased, being perhaps less active on the left.

On November 23, 1925, Dr. H. G. Tobey reported on the nose and throat as follows: "There is distinct evidence that the sensation is returning in the left nasal chamber. A year ago the mucous membrane was practically anæsthetic. There are no signs of infection in the sinuses or in the tonsils. The audiometer shows normal hearing in both ears. There is no nystagmus or vertigo suggesting any interference with the semi-circular canal, for this reason I have not done a Barany test. The location of the pain over the left temporal region, and at times being referred to the post-auricular and cervical regions, would suggest that the pain might be due to a sphenopalatine. It is almost impossible to cocainize this ganglion through the nose on account of a marked deviation of the septum."

During the next year there was no great change; mild sedatives, rest and hygiene kept the pain within bearable limits. Electrical examination of the facial muscles on March 4, 1926, showed no R.D., but the muscles on the left reacted slowly to faradic current. During the next two years trichlorethylene inhalations gave some relief. A reëxamination on December 10, 1928, found conditions about as before; an accurate testing of taste showed absence of appreciation of salt, sweet, and sour on the whole left half of the tongue; the anterior two-thirds of the left half of the tongue was anæsthetic to touch; there was no such anæsthesia on the palate and fauces, but the mucosa of the left nasal cavity was hypo-æsthetic. At this time she first mentioned spasm in her tongue and throat, but was not much bothered by it. Deep pressure over the left carotid artery at the level of the upper border of the larynx caused a tingling and burning sensation in the left half of her tongue, more at the tip. Peet[4] has brought out that pressure over arteries may produce pain in the regions supplied by them.

In the spring of 1929 her left cheek began to be more red and swollen. Then on April 6 she found difficulty in eating anything solid, especially if it were dry, because it would set up a spasm of her tongue which interfered with swallowing and prevented speech. For three days she lived on liquids. At the same time the left side of her face became weaker. On April 12 the muscles of the left half of her face were paretic, obviously weaker than 1928, but there was slight movement. The left cheek was congested, red and œdematous. Tears kept running from the left eye and a thin serous fluid kept running from the left nostril. Sensory examination of the face showed no anæsthesia, and hypo-æsthesia only in a restricted area on the left jaw. The tongue was as before. The left half of the palate was hypo-æsthetic to touch and showed a diminution of the gag reflex. The whole left half of the face, scalp and neck was paræsthetic. The most interesting observation was made immediately after giving her a dry cracker to eat. She tried to swallow it and failed. After washing out her mouth, the examiner could see the spasm in the left half of the tongue. The right half appeared perfectly normal, but the left half was turgid; it curled up and squirmed in slow, worm-like movements, dragging the tongue into her left cheek and backwards. The spasm made the left half look narrower than the right. The attack lasted four minutes. Afterwards, for a minute or two, the patient was unable to protrude her tongue, but soon she did so and was able to move it in all directions. It then looked perfectly normal and showed no atrophy or weakness. On April 26, 1929, an examination corroborated the previous findings. (Fig. 3). During examination of the tongue, a spasm was set up by pricking the left side with a sharp pin, although no sensation of touch or pain was felt by the patient. Nevertheless, the spasm was felt as a disagreeable drawing sensation with dull pain. Additional abnormalities noted at this examination were: an area of skin hypo-æsthesia on the left thigh just below the level of the trochanter; stimuli here were poorly appreciated, but set up a disagreeable tickling paræsthesia; position sense was poor in the toes, worse in the left foot; abdominal reflexes were active and equal; plantar reflexes were normal on both sides, but pinching the dorsum of the left foot caused a withdrawal that looked like a defense

reflex; the deep reflexes in the arms were active, perhaps a little more active in the left arm; the knee-jerks were distinctly hyperactive, especially the left.

Since the lingual spasm was becoming so disagreeable and incapacitating, an operation was advised to cut the chorda tympani nerve, somewhat similar tongue movements having been seen experimentally in animals after stimulation of it. Accordingly, Professor Leroy M. S. Miner of the Harvard Dental School was called in consultation. On November 16, 1929, he performed a rapid operation, through the mouth under novocaine anæsthesia and resected about one inch of the left lingual nerve. The interesting part of the operation was that on making the central cut of the resection of the nerve, there was no pain reported by the patient, but when the distal cut was made there was a terrific spasm of pain which lasted for a short time, the pain extending down into the neck. On November 20 the stitches were removed and the patient was discharged on the twenty-sixth, ten days after operation.

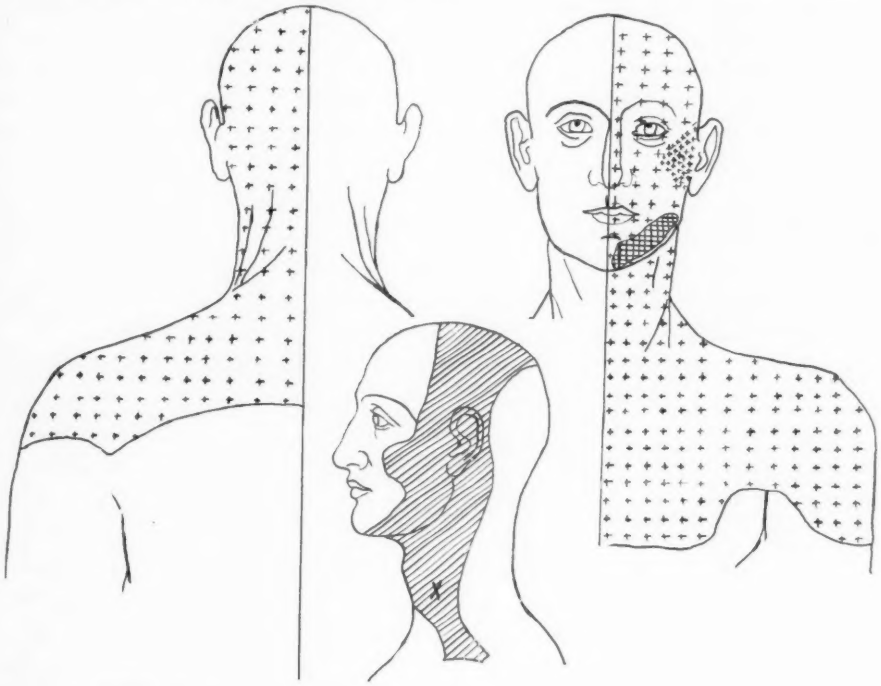

FIG. 3.— Tenderness and paræsthesia.

Hypo-æsthesia to prick and to brush.

Areas of spontaneous pain. X indicates a trigger point where deep pressure over the artery precipitated an attack of pain.

Since the operation, the lingual spasm has entirely stopped and up to January, 1934, there has been no recurrence. On March 11, 1930, a left cervicodorsal ganglionectomy was performed. This relieved the facial pain, improved the condition of the skin of the face, the lacrimation and the rhinorrhœa. Early in 1931 there developed a feeling of pressure over the lower end of the sternum associated with some difficulty in swallowing and dyspnœa.

At the present time she is having dull pain in the side of the neck running up to the ear. This has not been completely investigated as yet, but the pain seems to be similar in character to the pain she formerly experienced in her face. At the present time she has no pain in the distribution of the trigeminal nerve.

Discussion.—In our patient the sensory trigeminal nerve alone had been cut. The lingual branch had atrophied, but the autonomic branch from the geniculate ganglion of the facial nerve joins the lingual nerve peripheral to the site of the neurotomy. The lingual nerve, therefore, functionally remained only as a vasodilator to the tongue. The motor innervation to the tongue was intact. The spasms were associated with vasodilatation of one-half of the tongue and they ceased after section of the linqual nerve.

From this case report it seems that we have observed a pseudomotor phenomenon different from any that has yet been described. Superficially the contraction of the tongue in these patients resembles closely that described by several physiologists. When the neurophysiology of the different forms of pseudomotor activity is examined, it appears that our human cases lack one great essential, the sensitization of the affected muscle by motor denervation. Nevertheless, the phenomena have enough in common, so that a brief résumé of the experimental work is pertinent.

Vulpian in 1863[5] and Heidenhain in 1883[6] showed that section of the motor nerve (XIIth) to the tongue caused paralysis and atrophy, but that stimulation of the lingual (sensory branch of the Vth) nerve, which contains at that point the parasympathetic fibres of the chorda tympani, would cause a slow contracture of the tongue. The movements as described by them and later by Langworthy[7] were apparently like those observed in our patient. They came on after a long latent period. They were only observed in the tongue after partial degeneration of the hypoglossal nerve had taken place.

Gasser[8] states that sensitization of the muscles seems to result from degeneration of the motor fibres, in tongue experiments on the XIIth nerve. Stimulation takes place by way of the chorda tympani. The actual mechanism by which this acts on the muscle fibres is unknown, and it may be that the unknown element lies in the physiology of the peripheral blood-vessels.

From recent studies of contracture, Hinsey and Gasser[9] believe that the association of lingual contracture with vasodilatation is well recognized, but that the contracture is to be interpreted as being associated with the dilator mechanism rather than with the dilatation itself; it is quite independent of any turgescence produced by the latter and represents a real contraction of the muscle fibres themselves. They go on to discuss the possibility that the stimulation of the vasodilator nerve produces a chemical substance that reaches the striated muscles by humoral transmission. This substance resembles histamine and may actually be acetylcholine. Wolff and Cattell[10] have recently reviewed the physiological aspects of this subject in a most

thorough way, and have reported experiments which leave little doubt as to the correctness of the humoral theory. They conclude that humoral transmission explains these hitherto obscure phenomena.

The facts brought out by these experimental investigators correspond well with the symptom of lingual spasm as observed by us, except in one important point. In the experimental animals, in order to bring out the contracture, it was necessary to sensitize the muscle of the tongue by motor denervation; the experimental stimulation *via* the lingual nerve was carried out after motor nerve degeneration, but before much muscular atrophy had taken place. The exteroceptive sensory and autonomic innervation remained normal. In our patient the motor innervation was normal, but the symptomatology clearly indicated that the autonomic innervation was hyperactive. The sensory innervation had been removed by the trigeminal neurotomy six years before the onset of the lingual spasm. What caused the sensitization of the tongue muscle in these human cases we do not know. Apparently in all of them the autonomic system was abnormal, as evidence by the atypical neuralgia. The operation on the reported case proves that the stimulation to the tongue was by way of the chorda tympani fibres in the lingual nerve. More cases must be studied before further conclusions are justifiable. We believe that a survey of a large group of cases of trigeminal neuralgia, especially the atypical cases, will bring to light more examples of lingual spasm, and the authors would appreciate it if any physician who has observed this phenomenon would communicate with them.

SUMMARY

The symptom of lingual spasm associated with atypical trigeminal neuralgia is described. It appears to be a pseudomotor phenomenon.

The relationship of this symptom to Vulpian's lingual contracture is discussed.

The spasm may be relieved by cutting the chorda tympani fibres in the lingual nerve.

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OPHTHALMIC SYMPTOMS IN BRAIN ABSCESS

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The purpose of this paper is to present, without elaborate discussion, an analysis of the ophthalmic data as noted in forty-four case records of brain abscess. Access to these records was made possible by the courtesy of Dr. Charles H. Frazier, head of the department of Surgery. Only those cases were chosen in which the diagnosis was verified either by operation or post-mortem examination, and in which an adequate eye examination was made. It should be stated, however, that in numerous instances in which patients were too ill to coöperate, certain tests, such as the taking of visual fields, pupillary reactions to accommodation and convergence, visual acuity and rotations of the globe, could not be properly done.

The lesions are grouped as follows:

Frontal lobe abscesses	17
Temporal lobe abscesses	9
Parietal lobe abscesses	7
Cerebellar lobe abscesses	7
Occipital lobe abscesses	4

Only the positive and pertinent ocular signs and symptoms will be discussed in this analysis. For example, blurred disk margins without other changes are not taken into consideration. In one case of parietal lobe abscess in which the nerve heads were healthy, the retinal arterioles showed well advanced sclerosis and one small hæmorrhage was seen in the periphery of the retina. This condition, it is felt, was a mere coincidence and irrelevant.

Frontal Lobe Abscess.—Of the patients with frontal lobe abscess five had exophthalmus, swelling of lids, chemosis of the conjunctiva and pain; seven showed orbital involvement without exophthalmus; one had pain and tenderness of the globe; and one a lagophthalmus, part of a seventh nerve palsy. All these findings occurred on the same side as the abscess. Of the seventeen cases no orbital involvement was found in four and one of these four presented a lagophthalmus. More or less restriction of movement was noted in every case with exophthalmus, and among the others was one with complete ophthalmoplegia, two with paresis of the superior rectus, and one with ptosis; all on the affected side. In one patient the conjugate movement in the opposite direction to the site of the abscess was limited. In one, without proptosis, the homolateral eye was directed straight forward while the other eye turned up and out. In this patient as well as in two others, one of whom had the complete ophthalmoplegia, the pupil on the affected side was wider than the other and both were fixed. Thus of the seventeen

frontal lobe abscesses, there was more or less restriction of either the lids or of the eyeball or both in fourteen and in three of these the sphincter of the iris was also involved.

Frank choking was found in fourteen (82.3 per cent.) of this group, always bilateral when seen (one patient had a dense leucoma in the homolateral eye, obstructing a view of the fundus), varying from 1.5 to seven diopters at the height. The average peak was about four diopters. Of the twenty-eight choked disks sixteen were of the succulent type, in five of which no hæmorrhages or exudates were seen until after operation. In three instances the choking was higher in the homolateral eye, in three it was lower and in seven it was the same in both eyes. A choking of five diopters was seen in the contralateral eye of the patient with the opaque cornea. In one patient, with seven diopters of choking in each eye, there were no hæmorrhages or exudates on the affected side, while the choking in the other eye was of the succulent type. In another the choking was lower, with no hæmorrhages or exudates in the homolateral eye; higher and with a large hæmorrhage in the other eye. One patient presented an incomplete star-figure in the macula of the contralateral eye, the one in which the choking was lower.

Of the ten patients who had choked disks at some time during hospitalization, on whom operations were performed, immediate improvement which continued until complete recovery was noted in two, no change until death in four and immediate increase of elevation and severity of the choking after operation in four. In one of the latter patients the nerve heads were normal until operation, after which papillœdema developed and gradually increased until, two weeks after operation, the elevation reached a height of 2.5 diopters in each eye. After this it gradually subsided. In a patient with two diopters bilateral papillœdema without hæmorrhages or exudates, the elevation rose to four diopters in the homolateral eye and to 2.5 diopters in the other, with an incomplete stellate figure in the contralateral eye, and with many hæmorrhages and exudates in both. After this the choking subsided, the nerve heads becoming atrophic. In another patient with bilateral, dry choking of two diopters, the condition gradually increased in severity after operation until one month later there was a choking of four diopters and many hæmorrhages and exudates in each eye. From then on the condition gradually subsided. The other patient was operated upon six times. After the first operation the choking decreased from four diopters to three. Two days after the next operation, which was performed ten days later, the choking measured four diopters in the corresponding eye and five diopters in the other. Another operation was performed, and four days later the choking measured six diopters in each eye. Six days after the next operation the choking had subsided to 4.5 diopters in each eye. Two more operations were performed, but the elevation of the nerve heads remained unchanged until the death of the patient.

An upper bitemporal quadrantanopia was disclosed in one case, the only one of the seventeen in which a material field defect occurred.

There was only one in this group in which no ocular signs or symptoms were found.

Temporal Lobe Abscess.—No involvement of the lids, conjunctiva or evidence of extra-ocular muscle palsy was seen in any of this group. Fine nystagmus on extreme lateral turning was observed in one, and in another a fine nystagmus on looking laterally in the opposite direction to the lesion. Inequality and sluggish reaction of the pupils to light occurred in two instances; the smaller pupil on the side of the lesion in each.

Choked disks were noted in five (55.5 per cent.) of these nine records. They varied from one to five diopters at peak, an average of 3.9 diopters. In three the choking was always greater in the homolateral eye; in one it was lower at first and higher later; and in the other the amount of choking was the same in both eyes at first and became greater in the corresponding eye later. In one case the papillœdema was of the dry type, in one it was dry at first but hæmorrhages and exudates developed later, and in the other three the choking was of the succulent type throughout. All of the five patients with choked disks were operated upon, with a subsidence in four. The other patient showed no noticeable change until he died, five days after operation.

Homonymous hemianopic fields, corresponding to interference along the optic tract on the side of the lesion were found in three cases. Homonymous hemianopia on the opposite side was found in one and a corresponding inferior homonymous quadrantanopia in another.

Of the nine patients one had no ocular signs or symptoms whatever.

Parietal Lobe Abscess.—What was thought to be a paralysis of both external recti muscles was found in one of this group. Nothing pertaining to external ocular signs was noted in any of the other six case reports. In one patient the pupils reacted sluggishly to light, in another there was distinct hippus.

Choked disks were seen in three patients (42.8 per cent.); up to six diopters in each eye of one, four diopters in each eye of another, and five diopters in the homolateral and four diopters in the contralateral eye of the other. The peak average for the six eyes was 5.3 diopters. Every one of these choked disks was of the dry type. Thus in two cases the choking was the same in both eyes, and in the other it was higher on the affected side.

The three patients with choked disks were operated upon with the following results: In one no change was seen in the elevation of the nerve heads during the interval of three weeks between the operation and death. In the second patient the amount of swelling increased three diopters and remained at about the same level until he died, twelve days after operation. The third had a choking of five diopters in the homolateral eye and four diopters in the other. Nine days after operation it was six diopters in each

eye. Another operation was performed twelve days after the first and on the next day the choking was 3.5 and three diopters. A third operation was performed five days after the second with no immediate change in the disk levels. Two weeks later the choking measured four diopters in each eye.

One patient, with no other signs than slightly blurred nasal borders of the disks, had a homonymous hemianopia which did not correspond to the location of the abscess.

In three of seven cases of parietal lobe tumor there were no ocular signs or symptoms.

Cerebellar Abscess.—Of the seven patients with cerebellar abscess, paresis of conjugate upward rotation occurred in one and nystagmoid movements in six, one on lateral turning of the eyes toward the affected side and in the same direction, one toward the opposite side and in the same direction, one in the direction of any movement away from straight ahead, one in the same direction both on looking toward the affected side and upward, and two in the same direction toward either side. In one patient the head was turned toward the lesion, but the eyes were not turned. Pupils were always equal; fixed in one case, sluggish in another and normal in five.

Definite choking was found in three instances (42.8 per cent.) and was the same in both eyes in every case. One patient showed choking of the succulent type, reaching five diopters in each eye, but higher on the affected side at first. The other two showed dry choking, seven diopters in one and three diopters in the other. The average peak was five diopters. In one of these there was no change in the condition after operation. In another, in spite of two operations, the choking gradually rose in six weeks from three diopters in the homolateral eye and 2.5 in the other, to five diopters in each eye. After operation on the third of these three patients, the choking, seven diopters, subsided very slowly, still measuring six diopters in each eye at the end of two weeks.

One of this group had a superior quadrantanopic cut in the fields opposite to the side of the lesion, and one had small, absolute central scotomata with a peripheral nasal cut in the field of the eye on the affected side. The latter patient also, during convulsions, turned the head and eyes outward, away from the side of the lesion; but the findings here are of little or no value from the standpoint of localization, because of marked secondary, internal hydrocephalus.

In one of these seven cases no ophthalmic signs or symptoms were seen.

Occipital Lobe Abscess.—Four occipital lobe abscesses were recorded, in one of which was a bilateral ptosis, a patient with basilar meningitis. In one patient the homolateral pupil was smaller than the other, both reacting normally.

The optic nerve-heads were affected in all four cases. In three (75 per cent.) definite, measurable choking was found ranging from two diopters in the lowest to eleven diopters in the highest (the highest in the entire survey); in the other case the disks were hyperæmic with fluffy borders and

venous engorgement. The average peak height for the affected nerve heads was 5.8 diopters. The amount of choking was the same in both eyes of two cases and higher in the contralateral eye in the other. It is interesting to note that these were all true papillœdemas, that is, with no hæmorrhages or exudates. Of these three patients, one died shortly after operation without notation of fundus change. In one, with choking of four diopters in the homolateral eye and five in the other, improvement to 3.5 and one diopter took place before operation, and this improvement continued until he died ten days later. Just before death the only ocular pathology noted was a 1.5 diopter elevation of the nasal margin of the disk of the homolateral eye. In the other patient, with eleven diopters choking in each eye, the swelling came down to eight diopters two days before he died.

In the patient with associated basilar meningitis, the eyes were constantly turned in a direction opposite to the lesion. The head was not turned, but the patient lay on the side corresponding to the lesion.

Two patients had homonymous hemianopia corresponding to the side of the lesion. One of these was the only one who showed no distinct, measurable choking.

SUMMARY.—Swelling of the lids, chemosis of the conjunctiva, ocular pain and exophthalmus were seen only in the frontal lobe cases, but one or more of these signs occurred in over 84.5 per cent. of this group. Exophthalmus occurred five times in the entire series, and all with frontal lobe abscesses.

Including the five instances of definite exophthalmus, restriction of ocular rotations was found as follows:

Frontal lobe abscess	14
Temporal lobe abscess	0
Parietal lobe abscess	1
Cerebellar lobe abscess	1
Occipital lobe abscess	1
Total	17

Most of the muscular restrictions associated with frontal lobe abscess are certainly due to orbital cellulitis as part of the process, nevertheless they seem to be very important signs in frontal lobe abscess. But while the same may be said of the exophthalmias reported in this series, Holloway[1] found exophthalmus eight times in fifty-five cases of fibroblastoma and seven of these eight exophthalmias occurred in his group of twenty-one frontal lobe tumors. In every instance in which the exophthalmus was unequal or unilateral, the homolateral eye was more prominent. Frazier[2] found twenty exophthalmias in seventy-eight cases of frontal lobe tumor. Elsburg, Hare and Dyke,[3] on the subject of unilateral exophthalmus in intracranial tumors, found unilateral exophthalmus in fifteen patients, all with tumors situated in one or both sides of the anterior cranial fossa or in the anterior part

of the middle fossa. Chemosis of the lower or of both lids and more or less congestion of the conjunctiva were often observed.

In view of the frequency with which the extra-ocular findings were noted in the present group of frontal lobe abscesses, it seems remarkable that they have been so seldom emphasized. For example, Lilly[4] stated that in all of the groups of the cases of brain abscess at the Mayo Clinic, oculomotor paralyses were of no clinical importance in determining the site of the abscess. Benedict,[5] discussing brain abscess from the standpoint of the ophthalmologist, referring probably to the same cases as Lilly, made a similar statement and never mentioned exophthalmus or orbital involvement in his discussion, although he did refer in his summary to swelling of lids and face; yet among three of four case histories which illustrate his article two were of patients with frontal lobe abscess, one with homolateral exophthalmus and diplopia, and another with a history of severe swelling (homolateral) of the lids. The third, a patient with an abscess of the left temporal lobe, had a moderate contralateral exophthalmus with partial paralysis of the sixth and seventh nerves. Coleman[6] reporting twenty-eight cases of brain abscess, with comment on the ophthalmological observations, stated that the ocular muscle palsies were of little importance. Of the ten frontal lobe abscesses in the series bilateral paralysis of the external rectus was found in one and a homolateral ptosis in one other. Parker[7] reported the findings in twelve frontal lobe abscesses among a series of twenty-five brain abscesses. He mentioned a sixth nerve palsy in a patient with temporal lobe abscess and a loss of conjugate movement of the eyes in a case of cerebellar lobe abscess, the only extra-ocular signs in his entire series.

The head and eye turning, described and considered an important sign by Meyers,[8] was noted in one case of cerebellar lobe abscess, but the head was turned away from and the eyes toward, not away from the side of the lesion, as found by Meyers. In another case of cerebellar lobe abscess, associated with hydrocephalus, the head and eyes were turned away from the side of the lesion, but this was only during convulsions. The eyes turned toward the affected side in one frontal lobe and away from the lesion in an occipital lobe case, types in which Meyers stated the sign is absent.

Nystagmus was found in ten instances, as follows:

Frontal lobe abscess	2
Temporal lobe abscess	2
Parietal lobe abscess	0
Cerebellar lobe abscess	6
Occipital lobe abscess	0
Total	10

The frequency of nystagmus, six out of seven cases, in the group of cerebellar lobe abscesses is striking.

The pupils were found to be affected twelve times. Iridoplegia was noted four times; once with equal pupils in a cerebellar lobe abscess, and

three times, with larger pupil on the affected side, in frontal lobe abscesses. Sluggish, equal pupils were found once with parietal and once with cerebellar lobe abscess. With two temporal lobe abscesses the pupils were sluggish and unequal, smaller on the affected side. One example of active but unequal pupils, smaller on the affected side, was noted in a record of occipital lobe abscess. Hippus was seen with a parietal lobe abscess. Thus of the six instances of the fixed or sluggish and unequal pupils, all three in which the larger occurred on the affected side were found in frontal lobe abscesses.

Field changes were found in eleven records and of these only seven could be considered as an aid in localization. Useless from the standpoint of localization, were the three instances in which homonymous hemianopia was found in the field on the same side as the lesion, and in the cerebellar lobe abscess in which the symptoms were masked by secondary hydrocephalus. Thus of the entire series, in only seven cases were field defects of any localizing value, four of the nine temporal, two of the four occipital and one of the seven cerebellar lobe abscesses.

Eagleton[9] lays great stress on the importance of the localizing value of the fields in brain abscess and insists that routine fields should be taken daily. But, since nearly all of the patients in this series were seen in the late second or third stage of the disease, comparatively few could have the fields satisfactorily tested, and of these, it seems, from the results of the present series at least, that the field changes are of minor localizing value and even misleading in a considerable percentage of cases.

Frank choking was found in twenty-eight of the forty-four patients (63.6 per cent.) with the following number and percentage in each group:

Frontal lobe abscess	14	82.3 per cent
Occipital lobe abscess	3	75 per cent
Temporal lobe abscess	5	55.5 per cent
Cerebellar lobe abscess	3	42.8 per cent
Parietal lobe abscess	3	42.8 per cent

It was bilateral in every case in which the disks could be seen.

The average peak height of choking for each group arranged in the order of severity was:

Occipital	5.8 diopters
Parietal	5.3 diopters
Cerebellar	5 diopters
Frontal	4 diopters
Temporal	3.9 diopters

Choked disks, generally conceded as the most common ocular sign in brain abscess, were found to be even more frequent (63.6 per cent.) in this series than a casual review of the literature reveals for any like number of cases reported. Benedict[5] stated that it is present in about one-third of the cases. Coleman[6] found choking in fifteen of twenty-eight brain abscesses (53.5 per cent.). Hill,[10] properly including those conditions that were con-

sidered to be optic neuritis, stated that there were 44 per cent. of choked disks in Uthoff's often quoted series. Parker[7] found 56 per cent. in his series of twenty-five cases.

The comparative frequency of choked disks associated with abscesses of a particular locality, varies considerably with different reporters, and is due, presumably, to the small number reported by each. This applies also to the degree of choking. As a matter of fact the height affords little information in regard to the severity of the brain lesion. It is also considered by many that not much reliance can be placed on the degree of swelling in each eye as an indication to the side of the abscess, although in the present series the highest choking was homolateral in nine, contralateral in four and equal in fourteen.

That choked disk in brain abscess is due to increase of the intracranial pressure, and not to a possible absorption of toxic material, as has been so frequently stated, is well borne out in this series. For some time during, or throughout the entire recorded course of their illness, fourteen of the twenty-eight patients with affected nerve heads had pure papillœdemas; that is, six of the fourteen frontal, two of the five temporal, all three of the parietal, two of the three cerebellar and all three of the occipital lobe cases with choking, showed no hæmorrhages or exudates.

On the other hand, it is interesting to note that in thirteen patients the degree of choking remained the same or even increased, after operation.

One or more ocular signs or symptoms were found in all except six of these fourty-four cases of brain abscess.

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THE RELATION OF OPHTHALMOLOGY AND OTHER DEPARTMENTS AT THE UNIVERSITY HOSPITAL

SOME REMINISCENCES

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It is the object of this communication to endeavor to write in reminiscent manner about some of the departmental intimacies as they have existed at the University Hospital for the last half century, to gather some historical data, to call attention to a few records of achievement, some comparatively recent, and to weave the material into an unpretentious narrative. An admirable communication by Mr. F. A. R. Stammers[1] indicates how clearly our English confreres recognize the necessity of the association to which reference has been made.

February 3, 1874, ought to have a special mark on the calendar of events of the University Hospital, because on that day William F. Norris was elected Clinical Professor of Ophthalmology in the School of Medicine of the University of Pennsylvania. Richly endowed with the results of work in the great clinics of Vienna, he properly maintained specialization in ophthalmology, without for a moment losing his intimate relation with the lessons of general medical and surgical training, partly acquired during the Civil War. He was, indeed, a "specialist" of the proper breed who realized the value of coördinated work and utilized it.

From the very beginning of his activities he was keen to make and to direct routine ocular examinations of patients in all of the wards and to encourage coöperation in this respect with the dispensary services. To promote this enterprise, *i.e.*, the ocular examinations of suitable patients in all departments, he appointed on his staff the present writer after he had completed his interneship in the University Hospital (1882) and charged him "with special duties pertaining to the relation of general and eye disorders," duties which were systematically carried out, until the plan worked smoothly, under Doctor Norris' direct supervision.

Naturally, ophthalmoscopy played the most prominent rôle in this work, and in the neurological department of the hospital in the earlier period, Dr. Horatio C. Wood, Dr. Charles K. Mills, Dr. Hendrie Lloyd and for a time Dr. Francis X. Dercum supplied much of the interesting material from their clinical services; Doctor Spiller's important relation to this work belongs to a later date. Neurosurgery had not at this period (1883–1902) been conspicuously introduced into the picture except as shall presently appear.

A rich field for ophthalmoscopical work was afforded by the medical department of the hospital and the medical dispensary. The value of ophthalmoscopical diagnosis was early fully realized and utilized. Indeed,

Doctor Norris was from the beginning of his service interested in ophthalmoscopy—an interest which has steadily continued and increased since those early days, and a record of ocular examinations has for a long time been a *sine qua non* in the case histories of the medical wards.

It is not inappropriate to emphasize the fact that the department of ophthalmology of the University Hospital has always been noted for its close relation to general medicine and surgery and secondarily for its excellent results in the correction of refractive anomalies, largely owing to the work, in these early days, of Dr. James Wallace, who was in charge of the refraction department.

Patients from the dispensaries were sent to the out-patient department of ophthalmology for examination, where the source of illumination for ophthalmoscopical investigation was an Argand burner (hand electrical ophthalmoscopes were not available at that period). But in the ward, examinations of those patients unable to come to the out-patient department were made by candlelight, which was for the most part the only available source of illumination in such circumstances in those early days. The Loring reflecting ophthalmoscope was usually the instrument of choice.

We hailed at that time with delight a contrivance for improving illumination designed by Priestly Smith, namely, four candles pressed close together and mounted on a narrow board so that their united flames were blended into one—a real advance—as the larger flame was less susceptible to the influence of the breathing of patients or doctor than a single candle flame; indeed we learned to "hold our breath," as the saying is, for very long periods of time, and thereby enhanced the steadiness of the flame. And yet, with all these inconveniences, how well Doctor Norris read the story which the ophthalmoscope revealed; how well he taught those who followed in his footsteps to interpret the appearance of the fundus picture. Candlelight is, as it were, sanctified, for if the story is true, it was to a candle flame that Helmholtz turned for illumination seventy-four years ago when he devised the ophthalmoscope and exclaimed "and for the first time I had the pleasure of looking into the living human eye," and a new science was born—the science of medical ophthalmoscopy.

Naturally, the ophthalmoscopy of today is a far more revealing science than it was forty or fifty years ago owing to the improved methods of illumination and ophthalmoscopical construction. And yet it may be safely asserted that few of the essential details escaped the trained observer of the period to which we have referred.

Visual Fields.—Of course, visual-field examinations formed an essential part of the investigation of patients referred from the various clinics, particularly those from the neurological service. Indeed, Doctor Norris was especially interested in the results revealed by careful perimetric and campimetric work. It was quite inspiring to note the nod of approval with which he accepted for his inspection, carefully worked out and recorded visual

fields, and it must be remembered that inspiration was needed; assistants were not always keen about "taking fields" (to use the common expression), especially when the hour was late and the outer world tempting.

At that early period (almost half a century ago) the "dispensary perimeter" consisted of a complete metal hemisphere, not a metallic semicircle, and just above the fixation spot a small peephole had been drilled, through which an observer could watch the patient and note whether fixation was steadfastly maintained. It was a rather fearsome and cumbersome affair, but used properly, the results were good.

However, a much preferred apparatus was a long slate, mounted and framed, conveniently ruled in squares; the patient's eyes twenty-five centimetres from the board, fixed a white mark. The test objects, one centimetre square, were mounted on long black rods. With this much employed apparatus, which was a glorified campimeter, excellent results were achieved, and within 45° from the centre they were most accurate. It is still in use.

Indeed, this apparatus (designed or at least suggested by the late Dr. James Wallace of the eye dispensary, who was a mathematical genius) and the De Wecker campimeter would have yielded results as good as any obtained at the present time had we realized or been familiar with the value, indeed, the necessity, of quantitative perimetry, that is, the reaction of the visual field to different-sized test-objects, a technic which received its early impetus after Bjerrum, in 1899, announced his method, and which is especially indebted to the later work of Rönne and Traquair.

The search for scotomas, central, peri- and para-central was not neglected, and in these examinations test objects of small and varied size were used, being white and colored, and some rather good studies of the characteristics of the scotomas of toxic amblyopia (tobacco and alcohol amblyopias) were made. Why we did not vary the size of the test objects while mapping the general fields is not clear. However, it was not long thereafter that quantitative perimetry made its appearance.

In endeavoring to assist the neurological department, and later that of neurosurgery, in their study of the localization of intracranial lesions, naturally complete investigations of the eyes from all standpoints were undertaken. But although the fundus might show the well-known signs of increased intracranial tension, they were devoid of localizing value, and in this respect the visual fields were of prime importance, aided by a study of the balance or imbalance of the exterior ocular muscles and of the pupil reflexes. We understood perfectly this fact and felt a definite responsibility which precluded careless visual field work.

After the present writer was called to the Chair of Ophthalmology in 1902, he naturally continued the work which has been described and with which he had for about twenty years had an intimate association, and was ably assisted by members of his staff. With refined technic, newer types of instruments and improved illumination, visual-field investigations grew steadily in importance, especially noteworthy in relation to the localization

of intracranial lesions and the fundus examination of patients in the medical wards.

Sunday morning offered a useful time for ophthalmoscopical investigations, which could then often be undertaken in association with the medical or neurological chief, when, as it were, we walked the wards together. An even more intimate type of coöperative work was attempted at a later period (1916) by Drs. Alfred Stengel and Edward Martin and the writer, in that they combined their demonstrations during the same hour. For instance, during the lecture demonstration of cardiovascular or renal disorders the ophthalmoscopical pictures of such disorders were demonstrated by the writer. Admirable water-colors of eyegrounds prepared by the late Miss Margaretta Washington were utilized for this purpose; or when the surgical relief of increased intracranial pressure was the subject of a lecture-demonstration by Dr. Edward Martin, the fundus lesions of such intracranial pressure, chiefly the different stages of choked disk, were depicted by the writer with the aid of a lantern. And these water-colors were such as had been obtained from patients then in the hospital, or who had been there. This proved to be an interesting blend of two departments. Unfortunately, the Great War began and the technic fell into disuse, because the various departments were depleted. But the plan was a good one and should be restored.

In 1924, the present writer retired from the Chair of Ophthalmology and was succeeded by Dr. T. B. Holloway, who had been associated with him during the entire period of his service. Doctor Holloway's interest in the relation of ophthalmology to neurology and neurosurgery, as well as general medicine, never flagged, and the essayist hopes Doctor Holloway's long association with him may have helped to stimulate his enthusiasm and to create the excellent results which he has achieved.

Among the foremost of these was the establishment in 1926 of the Laboratory of Perimetry at the University Hospital, fully equipped in every respect, with calculated and regulated illumination, and placed in charge of Dr. Hazel Wentworth, Ph.D. of Bryn Mawr College and an expert perimetrist. Doctor Wentworth is easily familiar with all that pertains to modern perimetry and has at her disposal all the necessary perimetric and compimetric appliances.

Counting all the fields which have been mapped in this laboratory, not only those of patients in the neurological and neurosurgical departments, but also those from the general medical wards, about 4,500 examinations have been made. Copies of all fields are retained and all are indexed and cross-indexed. Of course other fields have been mapped by other members of the ophthalmic staff, especially in the out-patient department; with this work Dr. Alexander Fewell has been especially concerned.

Has the writer dwelt too long on field work? He thinks not, and is sure Doctor Spiller and his staff and Doctor Frazier and his staff will readily testify that they are materially aided in solving many of their problems

because of accurate perimetry, and the department of medicine will add similar testimony.

It is not too much to say, as the writer has elsewhere written, "visual-field testing is a method of precision of paramount importance in neuro-surgical work, and requires and receives here and elsewhere a technic as exact as that of the surgical procedures contemplated." At present Doctor Holloway appoints one member of his staff to a three-months service who shall keep his department in touch with the departments of neurology, neuro-surgery and medicine. This is exactly the kind of coöperative work which Doctor Norris introduced well nigh half a century ago when the present writer was assigned to this duty, which has been referred to in an earlier portion of this paper.

BRAIN SURGERY.—This was practised by the University surgeons at a fairly early date. For instance, Dr. J. William White[2] states:

"In one of the earliest cases of so-called brain surgery which occurred in Philadelphia, I trephined a patient for Dr. C. K. Mills over the course of the longitudinal sinus and removed from beneath the dura a fragment of bone and a small pistol ball, together with some surrounding sclerosis and adherent brain tissue, with the result of curing the patient of an inveterate epilepsy."

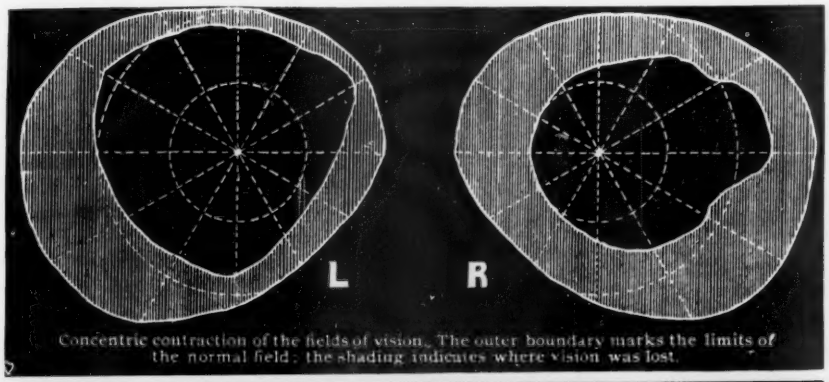
Doctor White does not give the date of this operation, and we cannot be absolutely sure that it was performed at the University Hospital, but it seems more than probable that he used his hospital facilities for this and other similar operative procedures.

But in so far as the writer is able to ascertain, the first operation at the University Hospital designed for the purpose of removing a brain tumor was performed at the request of Dr. Horatio C. Wood by Dr. D. Hayes Agnew February 11, 1889.* The patient, a clergyman, had been studied with great care and detail for a long time by Dr. H. C. Wood, the ocular examinations having been made by the writer. These studies revealed that the chief symptoms were headache, choked disk, left lateral hemianopsia and disturbance of the power of balancing himself[3] (Figs. 1, 2, and 3).

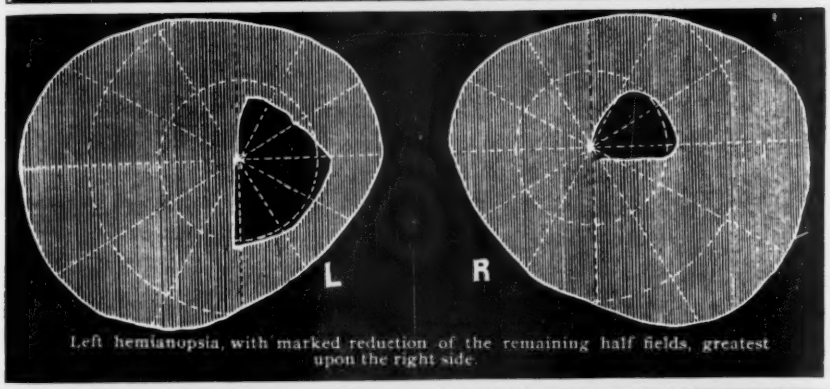
Doctor Wood, convinced that a lesion was present which interfered with the function of the cuneus, advised operation, which was performed, as before stated, February 11, 1889.

Thus Doctor White[4] describes the operative procedure and the result: "The first trephine opening was made at the lower internal angle of the right occipital lobe, the instrument being placed so that the teeth would clear the lines of the lateral and longitudinal sinuses from a quarter to a half inch, variations constantly occurring in the width. In spite of this precaution, it would appear that one of the large vessels was opened and a severe hæmorrhage occurred which was stopped by gauze pledgets, and a

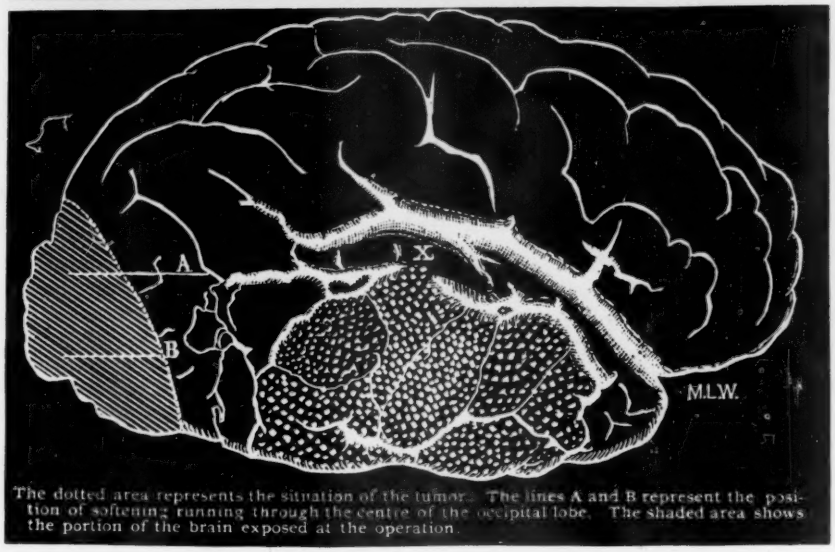
* It is interesting to note that the first successful operation for removal of a brain tumor in Philadelphia was performed by Dr. W. W. Keen at St. Mary's Hospital, Dr. William J. Taylor assisting. It was a meningioma (fibroma of the dura). This operation was described in a paper read before the American Surgical Association, September 18, 1888; *vide* Amer. Jour. Med. Sci., vol. 96, pp. 329–357, 1888.



Concentric contraction of the fields of vision. The outer boundary marks the limits of the normal field; the shading indicates where vision was lost.



Left hemianopsia, with marked reduction of the remaining half fields, greatest upon the right side.



The dotted area represents the situation of the tumor. The lines A and B represent the position of softening running through the centre of the occipital lobe. The shaded area shows the portion of the brain exposed at the operation.

FIGS. 1, 2 and 3.—Showing ocular findings in first case of operatively attacked brain tumor at the University Hospital.

second trephine opening was made over the region of the gyrus and the opening was made to communicate by means of the Rongeur forceps. A cystic deposit in the cuneus was recognized and removed, but evidently the main growth, namely, in the temporo-sphenoidal lobe, was not recognized as the factor which had produced in all probability the double choked disks and lateral hemianopsia."

In spite of the vagaries of the field depression (concentric contraction, later left lateral hemianopsia, complete temporary, blindness of one field, and finally a reproduction of the hemianopsia) which had been quite puzzling to the perimetrist, Doctor Wood believed that the lesion (tumor?) was in the cuneus, and when Doctor Agnew after the primary hæmorrhage was controlled was inclined to desist, he, Doctor Wood, insisted that the cuneus should be examined. This was done and the cystic process described above was exposed and removed.

Indeed, at this period the visual-field changes due to temporal lobe tumors, so well studied and classified by Cushing and Walker, were not recognized. But it is interesting to note that even if there had been no temporal lobe tumor, the cystic degeneration of the cuneus would have been quite capable of producing the hemianopsia, a fact upon which Doctor Wood had from the first insisted.

Doctor Frazier was elected Professor of Clinical Surgery in 1902, and twenty years later, after the retirement of Dr. Edward Martin, succeeded him as John Rhea Barton Professor of Surgery. The requirements of brain surgery had been of course duly undertaken as part of the duties of the surgical department in the person of Doctor Martin and his assistants, but we may well believe that very early in his surgical career neurosurgery began to attract Frazier's attention as something which should be established as a special division of the department of surgery.

In this earlier period just prior to its establishment, when it was noticeable where Doctor Frazier's energies were tending, some of us may have wondered why this particularly difficult line was chosen for special attention. Perhaps we were somewhat influenced by Sir William Osler's address delivered at the Orthopedic Hospital and Infirmary for Nervous Diseases in 1888, which did not exactly sound an optimistic note:

"Taking a large number of brain tumors," said Doctor Osler, "only a limited proportion could be operated upon with a prospect of recovering." Also, he quotes Dr. Alan Starr's "Analysis of Three Hundred Brain Tumor Cases," to the effect that in only 19 per cent. would surgical interference have been warranted, and "in only 16 might an operation have been successfully performed."

Of course these thoughts or these printed words may never have reached Doctor Frazier, and even if they had, it may be questioned whether they would have exercised any deterrent influence. We may be sure after Doctor Frazier made up his mind to devote a major portion of his time to neurological surgery, he steadily persisted until he gained his objective, and the depart-

ment of neurosurgery was established, which under his guidance has attained a world-wide reputation.

The first operation by Doctor Frazier in the Neurosurgical Clinic for the removal of a brain tumor (a sarcoma), the patient having been referred by Dr. Charles K. Mills, took place October 25, 1903, or only a year after Doctor Frazier's election as professor of clinical surgery, indicating, therefore, an early interest in the grave problems of intracranial surgery an interest not lacking in the work of his predecessor. An entirely satisfactory recovery took place. Not all intracranial neoplasms are "brain tumors." A number confined to the meninges have no organic association with the brain tissue; they are meningiomas. This distinction in the literature is not always as carefully made as is desirable. Doctor Osler in the article referred to and previously quoted makes this point.

At the present time (January, 1934) the office files of the Neurosurgical Department of the University Hospital in the charge of Doctor Frazier contain records of 1,101 intracranial tumors (344 cerebellar and 757 cerebral), and it is not difficult to envisage the activities which this large material has demanded from all standpoints. It would be beyond the scope of this narrative to discuss in detail the treatment of these cases, many of which have formed the bases of highly important communications by Doctor Frazier and members of his staff. Over a thousand intracranial tumors, excluding those of the pituitary body, are surely a goodly supply, even though they were gathered during thirty years.

Naturally, it seems to the writer that the deep interest which ophthalmology maintains in relation to intracranial disorders must be regarded as an important factor in, so to speak, "locating brain tumors." Intracranial growths are probably not more frequent now than they were twenty-five years ago, but they are more frequently discovered through the agencies of modern diagnostic efforts.

Sir Victor Horsley's insistence fifty-odd years ago, that release of intracranial tension by a cerebral decompression arrests and cures choked disk and thus prevents blindness, was indeed a happy one, and in this country was first put into practice by the late Dr. Robert Weir.

The procedure has been the means of saving sight in many cases in our neurological department and elsewhere, as well as relieving intense headache, vertigo, nausea and vomiting, and Dr. Edward Martin during his period of duty as John Rhea Barton Professor of Surgery, Doctor Frazier, his successor, Doctor Spiller and the late Doctor Mills have always been most insistent in pointing out the advantages of this important surgical procedure.[5]

In the writer's not inconsiderable experience the most prompt and complete result occurred in the case of a patient in the surgical ward of the University Hospital, Dr. Edward Martin, then John Rhea Barton Professor of Surgery having been the operator. The patient, a young man, experienced almost immediate relief; a swelling of each disk of 6 diopters subsided com-

pletely in less than a month; vision was restored, the location of the tumor, if it was one, was not detected; the condition was probably an arachnitis.

It is interesting to recall that the ancients knew something about this matter. In the Hippocratic writings (C8) occurs this paragraph: "When the sight fails in a person in good health, one must cut down upon the bone at the vertex, draw aside the skin, trephine the skull, and permit the escape of the exuded liquid. In this way the sight of the Blind is restored."[6] This is a useful anecdote to counteract claims of priority as to the utilization of cerebral decompression for the purpose outlined above should they arise, as, indeed, on several occasions they have arisen.

PITUITARY BODY.—A few early and some late experiences with respect to pituitary-body disorders may not be out of place. The hypophysis and its surroundings have claimed such constant attention, especially since the publication in 1911 of Harvey Cushing's incomparable monograph, that it would seem the impression is rather general that the knowledge of its disorders is a comparatively recent one. Certainly it is true in that attention has been centred on this area more intently for the last twenty-five years than in previous periods, which probably explains the apparently greater frequency of pituitary disorders now as compared with earlier days. But in general terms defective vision as the result of pituitary-body lesions constitutes an observation of ancient lineage; for instance, more than 200 years ago R. Vieussens noted and recorded "amaurosis" in these circumstances.

An early record during our generation by the present writer was published forty-seven years ago.[7] The principal symptoms were optic nerve atrophy, bitemporal hemianopsia, intense, chiefly occipital, headaches, nausea, dysmenorrhœa, and rapid increase in weight, which began when the patient was ten years of age. This paper contains references to pituitary-body disorders as published in England, France and Germany, and especially to acromegaly, but the despairing note that nothing could be done to stop the advancing process and that all remedies (drugs) were in vain sounds strangely now, and yet doubtless fifty years beyond the present date some of our therapeutic measures and our surgery will seem crude and insufficient. This case is mentioned simply because, so far as it is possible to ascertain, it is the first record of a pituitary-body disease, probably tumor, published in Philadelphia.

The files in Doctor Frazier's office contain at present the records of 372 cases classified as "pituitary lesions," and the first operative procedure took place July 18, 1912—the removal of a pharyngeal-duct cyst. One year later the first operation for removal of a tumor (adeno-carcinoma) was performed. Doctor Frazier uses the transfrontal approach in all his pituitary-body operations, the technic of which he has revised for both cosmetic reasons and to lessen operative mortality.

It is difficult to estimate the value of pituitary and thyroid extracts in the treatment of hypophyseal disorders, which represents a subject that cannot be conveniently discussed in detail in this paper. It is the writer's impression that in the Frazier Clinic the routine employment of these ex-

tracts, for instance, after operation, has been abandoned. The essayist, having secured by elaborate dosage of thyroid and pituitary extract the complete restoration of vision, direct and indirect, in two patients, the subjects of pituitary-body dysfunction, sight having practically disappeared in one of them while the other had temporary complete loss of vision, introduces this statement in these reminiscent pages because one of the patients was for a considerable time in the University Hospital, and her remarkable recovery interested all those who had examined her. The other patient (now active in her occupation—she is a nurse) was seen only recently; vision of one eye normal and the other not far from that; fields (once hemianopic) now perfect. It is possible that the startling recovery of these patients may have been due to spontaneous decompression. Also, they took large doses of mercury, although neither of them had syphilis. Is it possible that a synergic action, in that mercury and the extracts aided each other in stimulating glandular secretion, should be considered?

However, the evident conclusion of the matter is that patients put upon glandular extract therapy must keep themselves under constant observation, lest they disregard signs which point to the need of a much more radical procedure. Failure to do so has been disastrous in more than one instance.

Since Béclère's observation in 1908 as to the value of the radiotherapeutic treatment of non-malignant tumors of the hypophysis this method has advanced in favor. A few words may be introduced here as to the method as it is practiced at the University. No longer is radium used as the radiation agent, X-rays, according to Doctor Pancoast, being more efficient and more able to secure a deeper penetration.

At one time it was believed that radiation after operation prolonged periods of relief and prevented recurrence, but Frazier stated that a number of years must elapse before final confirmation of this belief can be definitely recorded. It is interesting, therefore, to record his present opinion: he believes radiation should be applied for the treatment of pituitary adenomata only in comparatively early stages, that is, before optic-nerve atrophy is advanced, irrespective of field deformations. When optic-nerve atrophy is pronounced, Frazier advises immediate operation. As a matter of fact, he reports he has had but one patient in whom radiation has been permanent in its effects; in all other cases recurrence followed radiation, and in the end surgical intervention was compulsory.

Doctor Frazier insists that in deciding these points the appearance of the optic disk must be the criterion and not field distortions. But of course the visual-field tests, so very important and informing in all types of pituitary-body dysfunction, must not be excluded from participating in such determinations. Certainly the so-called distinctive appearances of pituitary atrophy, the "glistening pallor," "the peculiar waxy pallor without shrinking," "the pallor associated with a yellowish tint" are not always present. Moreover, it may be difficult to decide whether there is any change in the optic-nerve ophthalmoscopically evident, and yet the fields may, when tested

by means of detailed perimetry with small test-objects, expose a depression or distortion of diagnostic and localizing importance.

There is perhaps no intracranial region whose lesions are better revealed by visual-field testing than those within the arterial circle of Willis and its immediate surroundings. But it must not be forgotten, as J. Parsons Schaeffer's very beautiful dissections have shown,[8] that the frequent asymmetry of the anterior cerebral arteries and anterior and posterior communicating arteries and their relatively large calibre may make them in certain circumstances definite pressure cords in relation to the optic-nerve chiasms and optic tracts, and complicate visual-field results. This fact, the writer feels sure (and his belief is based on considerable experience), accounts for some of the apparently contradictory evidence afforded by visual-field testing of lesions at the base of the brain.

Visual-field interpretations of the lesions in this area furnish a fascinating study, and we may be sure the charts prepared by Doctor Holloway and Doctor Wentworth will still further add materially to accuracy in localization, and that the possible sources of contradictory evidence have been fully considered.

Enough has been said, we think, to justify all that has been written about the value of accurate field work in elucidating many neurosurgical and neurological problems. Although visual-field testing has been emphasized as an aid in localizing brain lesions, tumors, for instance, of course röntgenography alone or in association with ventriculography, the interpretation of clinical signs of disturbance in various brain areas, *etc.*, receive their full measure of required attention.

But something should be said about neuroparalytic keratitis, which was common enough after resection of the Gasserian ganglion, and once more the "eye people" and the neurosurgeons combine. This type of keratitis was always helped and usually promptly cured by a median tarsorrhaphy, provided the lids were not separated for a long period of time. Whether holocaine persistently used prior to the operation and sulphate of chromium internally administered really did good, the writer is unprepared to say. But then came the advice from Spiller that section only of the sensory root should be performed and the first purposeful section of this sensory root took place November 12, 1902. The Frazier-Spiller operation lowered greatly the mortality of the prevailing resection of the Gasserian ganglion operation, the mortality of the radical measure being 22.5 per cent. and that of the sensory-root operation less than 0.5 per cent.

Although section of the sensory root alone was often followed by keratitis, the later modifications by Frazier, especially subtotal section of the sensory root, tended to prevent this complication. A recent note from Frazier is well worth quoting: "Because of Doctor Spiller's original contribution, the neurosurgical clinic has been somewhat of a clearing house for trigeminal neuralgia. In one way and another we have had contact with 1,854 cases of this affection. The radical operation has been performed 790 times."

Of the many other activities of the neurosurgical clinic we cannot do more than mention a few; they are not concerned with reminiscences but form records of distinguished merit.

In 1908, Frazier for the first time sectioned the auditory nerve in this country for the relief of persistent tinnitus and vertigo.

In 1912, Dr. Edward Martin, then John Rhea Barton Professor of Surgery, was the first surgeon to perform the operation designed by Doctor Spiller for the relief of pain dependent on malignant disease, namely, section of the anterolateral column of the cord.

Largely due to repeated publications by Doctor Frazier, the profession was gradually convinced of the usefulness of the Spiller operation, not only to relieve the pain of malignant lesions, but also that of non-malignant conditions, for instance, intractable sciatica, painful stumps, injuries of the lumbosacral plexus, post-herpetic neuralgia, *etc.*

Frazier was the first to perform intraspinal root anastomosis for urinary incontinence following spinal trauma and sectioned the posterior spinal roots for the relief of spasticity, following a suggestion by Dr. William G. Spiller.

In 1909, Frazier took exception to the prevailing practice of cerebral decompression in cases of cerebral trauma and paved the way to the present conservative practice. During the Great War decision as to the treatment of cranial injury was largely determined by frequent ophthalmoscopical examinations, watching whether choked disk supervened, and if it did so surgical interference was considered justified.[9]

This narrative is concerned only with the University Hospital and its activities. Of course the same type of coöperative work has formed and forms part of the technic of all important hospitals in our country and elsewhere, and it is gratifying to realize that independently of its specific importance ophthalmology has attained such an important place on the diagnostic index.

It is also gratifying to remember that the Chiefs of at least four of the great neurosurgical clinics of this land are graduates of the School of Medicine of the University of Pennsylvania and were trained in the neurosurgical department of its hospital.

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THE TREATMENT OF ACUTE AND CHRONIC CASES OF CEREBRAL TRAUMA, BY METHODS OF DEHYDRATION

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The treatment of acute cerebral trauma by means of "dehydration," had its origin in 1921 on the neurosurgical service of Dr. Charles H. Frazier. The encouragement and guidance extended to the author by his former Professor and Chief made possible the development of the present clinical program of "dehydration" and a better understanding of the principles involved.

The application of the principles of "dehydration" now extend into many neurosurgical problems, complicated by increased intracranial pressure, as well as acute and chronic "hydration states" arising throughout the general field of medicine and surgery.

It is a sincere pleasure at this time to dedicate to Doctor Frazier the author's observations on methods of "dehydration" employed in cerebral trauma during the past twelve years.

Introduction.—The term "dehydration" has been applied to clinical measures designed to subtract water from the body tissue reservoirs, the principal objective in cerebral problems being depletion of the large cerebrospinal fluid reservoir.

The first deliberate attempt to evolve a clinical program of "dehydration" followed observations on the rise and fall of the fontanel in infants, on the pædiatric service at the University of Pennsylvania Hospital, early in 1921. These clinical observations, as they apparently concerned intracranial volume relationships, were correlated with the then recent experiments of Weed and McKibben,[1] 1919–1921, showing a reduction of intracranial pressure following the intravenous and ingested introduction of hypertonic saline solutions.

The first opportunity to apply these observations clinically arose in September, 1921. A patient (I. R. S.), on the neurosurgical service of Dr. Charles H. Frazier, manifested signs of respiratory failure and cerebral œdema some hours following operation for a parietal lobe tumor of the brain. Large doses of magnesium sulphate were administered to the unconscious patient by a stomach-tube, in an attempt to reduce the cerebral œdema and pressure, when signs of a failing respiratory centre had developed. Following the administration of the hypertonic solution, the respirations rose promptly from a rate of eight per minute to twelve. The dose was repeated in four hours with continued improvement, and the return of the patient to consciousness (Fig. 1A).

At this time (1921), subtemporal decompression, ventricular puncture and spinal drainage were the accepted methods at the disposal of the surgeon

for relief of pressure in such desperate situations. The occasional use of concentrated solutions of sodium chloride, by vein, as advocated by Cushing and Foley,[2, 3] 1919–1920, produced temporary manifestations of benefit, although frequently secondary phases of pressure ensued which made the use of intravenous sodium chloride a measure of last resort.

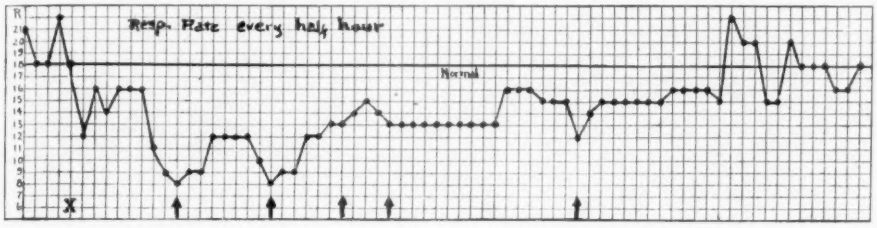


FIG. 1A.—(I. R. S.).—Rapid post-operative fall in respiratory rate due to medullary pressure, relieved by magnesium sulphate, with eventual recovery: *R*, respiration; *X*, exploratory craniotomy; arrows, magnesium sulphate. (Courtesy J. A. M. A.)

The beneficial response, due to "dehydration," by means of the introduction of a saline purge, such as magnesium sulphate, into the gastro-intestinal tract, was observed further when applied to cases suffering from acute cerebral injury due to trauma (Fig. 1B).

A routine method of treatment soon arose, designed to meet the needs of acute cerebral pressure problems, but the principles involved concerned those of chronic pressure as well, so that its importance became evident in the

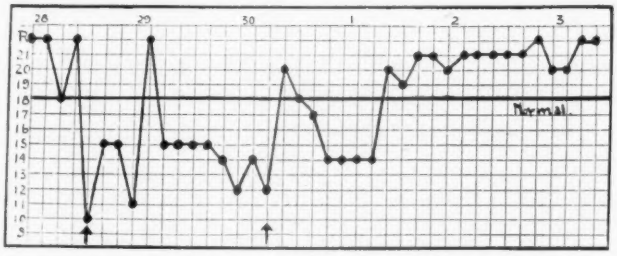


FIG. 1B.—(H. S.).—Respiration after concussion resulting from blow on head; medullary depression relieved by magnesium sulphate with rapid return of respirations to normal: *R*, respiration; arrows, magnesium sulphate. (Courtesy J. A. M. A.)

management of brain tumors, communicating hydrocephalus and other hydrated states such as epilepsy, eclampsia, and the various chronic post-traumatic-pressure syndromes.

The profound importance which the subject of cerebral trauma holds in our social and economic world today can be judged by a recent comparison of the losses in the American Expeditionary Force during the World War: "killed in action, 36,694; died of wounds, 13,691 or a total of 50,385."[4]

According to a report from the Surgeon General's office, "In 1928, 100,762 individuals in this country met violent deaths; and in 1929, 103,942 individuals died in the United States from violent causes."

A recent announcement by the National Safety Council (February 1,

1934), states that 33,000 individuals met violent deaths by motor-vehicle accidents, alone, in 1933.

No figures are available as to the proportion of these cases which received complicating cerebral injuries. The majority of deaths, due to violent causes, involve directly or indirectly the central nervous system.

Swift[5] states that there are approximately 112,000 cases of skull fracture annually in the United States, with an average mortality of 25 per cent. In his analysis, patients treated in private hospitals showed a mortality of 24.8 per cent., whereas the mortality in the county hospital was 35.5 per cent.

Wortis and Foster Kennedy[6] report a mortality of 37.8 per cent. in one thousand cases of cerebral injury admitted to the Bellevue Hospital between the years 1926 to 1929.

Mock, Morrow and Shannon,[7] in a wide survey covering 3,278 cases of cerebral injury, present the following table of comparative mortality rates:

	Cases	Deaths	Per Cent.
Hospital A	1,173	464	39.5
Hospital B	190	59	31.
Hospital C	32	13	40.6
Hospital D	34	11	32.4
Hospital E	114	37	32.4
Hospital F	191	57	29.8
Collected cases	800	209	26.
Doctor Fay's reports	224	41	18.3
Doctor Wright's reports	349	73	21.8
Mock's cases	171	33	19.2

These authors add, "At least three of the surgeons who have been concentrating their efforts on the management of skull fractures (Fay, Wright and Mock), have shown that the mortality rate can be reduced to around 18 to 21 per cent."

This is obviously a challenge to those who have made no effort to understand or cope with the problem of cerebral trauma, excepting to adopt palliative measures leading to a high mortality.

The importance of the problem in peace-time military circles is further indicated by the fact that during the ten years between 1922 and 1932, twenty-six officers and 398 enlisted men in the Army died of injuries received in automobile and motor-cycle accidents. This "class of accidents," according to Major G. F. Lull, M. C., U. S. Army,[8] "leads all others as a cause of death in the Army."

No figures are available as to the economic loss, in terms of individuals incapacitated by severe cerebral trauma, who have subsequently survived. The facts regarding the eventual institutionalization of the cerebral trauma patient (whether arising from outside accidental causes, or secondary to birth injury), are not available, but the chronic, mentally deteriorated, as well as the mentally retarded and post-traumatic deteriorated groups, constitute a large proportion of our institutionalized patients today.

The enormous financial burden imposed upon the people of the United States, to care for and maintain these victims of cerebral injury during the various subsequent periods of life, is beyond estimation.

It is obvious that the subject of cerebral trauma, its proper consideration and management, constitutes one of the outstanding problems before the medical profession today.

The material presented in this paper has been divided into consecutive yearly groups to indicate what general improvement in mortality may have arisen from the measures of "dehydration" as they became elaborated, and as a means of comparison between this recent method and other methods currently employed during the development of the program which has now become an established method of treatment for such conditions.

In spite of the wide variety of factors which have contributed toward the success or failure in the management of cerebral trauma, it seems evident during recent years that a general trend has occurred away from the former concepts of "surgical decompression" and toward the more conservative methods of "physiological decompression."

In order to definitely arrive at a comparative basis for such a study, all accident cases suffering from unconsciousness complicating injury, admitted to the hospital, have been included in this series. This is in order that deaths occurring within the accident ward, a few minutes or several hours after admission, may find their rightful place in the total mortality figures.

In the author's opinion, patients who have survived the three-hour period, after admission to the hospital, offer the possibility of analysis of treatment. The effect of treatment instituted immediately in the accident ward requires at least two to three hours to become adequate and effectual. On the other hand, patients who have received minor injuries without sufficient symptoms to warrant their final admission to the hospital service have been entirely excluded from this analysis.

It is therefore apparent in this series, which includes all major cases admitted to the hospital, irrespective of the survival period, that a clearer idea of the merits of treatment can be obtained in those patients who have survived at least the third hour after admission, and the introduction of treatment.

The hopeless group, with almost an "immediate" mortality (died within three hours) may serve to indicate the general character of cases received by the hospital services analyzed. The total mortality indicates the basis of prognosis justifiable from the moment of accident, whereas the hospital mortality after the third hour represents a fair comparative basis for treatments now employed.

Material Analyzed.—The following tables contain cases analyzed on three hospital services, covering a period of fifteen years, including twelve years of collateral growth of the method of "dehydration."

A control series from 1918 to 1921, in one hospital, serves to indicate the results obtained by former methods of treatment.

A parallel series of cases in the same institution observed from 1921 to 1925 serves to indicate the results obtained on those treated by measures of "dehydration" as contrasted to those treated by other current methods until the principal of "dehydration" became adopted (Table I, Series A).

SERIES A — TABLE I

Date	Total Cases		Deaths	Total Mortality	Died within Three Hours	Immediate Mortality	Died after Three Hours	Final Mortality
1918		94	18	19.6	4	4.2	14	15.5
1919		44	12	27.2	3	6.3	9	21.9
1920		70	15	21.4	3	4.2	12	17.9
1921	(Dehydration series)	14	1	7.1			1	7.1
	(Control series)	31	7	22.6			7	22.6
1922	(Dehydration series)	28	2	7.1	1	3.6	1	3.6
	(Control series)	19	6	31.6			6	31.6
1923	(Dehydration series)	21	3	14.3			3	14.3
	(Control series)	11	3	27.3			3	27.3
1924	(Dehydration series)	20	4	20.			4	20
	(Control series)	33	5	15.10	2	6.6	3	9.6
1925	(Dehydration series)	60	6	10			6	10
1926	(Dehydration series)	15	2	13.3			2	13.3
Total		460	84					
	(Dehydration series)	158	18	11.3	1.		17	10.8
	(Control series)	302	66	21.8	12.	2.7	54	18.6

In another institution, rotating services provided an opportunity to contrast results between the old and the new methods (Table II, Series B).

The series of cases treated from 1929 to 1934, at Temple University Hospital, on a full program of "dehydration" is contrasted with the results obtained three years prior to the establishment of the author's neurosurgical department, although the method had already been adopted in a modified form by his predecessors.

From 1929 to the present time, the full measures of "dehydration" and fluid limitation have been carried out on the neurosurgical service of Temple University Hospital with a total mortality of 18.2 per cent. and a final mortality (after the third hour) of 13.8 per cent. In contrast to these figures

the total mortality for the control series in the same institution for three years prior to the establishment of "dehydration," was 25.6 per cent. with a final mortality of 19.4 per cent.

The striking fact revealed by this study of 1,032 cases is that the *total*

SERIES B — TABLE II

Date	Total Cases	Deaths		Total Mortality	Died within Three Hours	Immediate Mortality	Died after Three Hours	Final Mortality
1925	(Dehydration series)	22	5	22.7	1	4.5	4	19
	(Control series)	9	4	44.4	0	0	4	44.4
1926	(Dehydration series)	13	1	7.6			1	7.6
Total Series B		44						
	(Dehydration series)	35	6	17.1	1	2.8	5	14.2
	(Control series)	9	4	44.4	0	0	4	44.4

mortality of the "dehydration" series (556 cases) has been definitely below the *final* mortality of the control series (476 cases) even after the number that perished in the first three hours had been deducted.

SERIES C — TABLE III

Date	Total Cases	Deaths		Total Mortality	Died within Three Hours	Immediate Mortality	Died after Three Hours	Final Mortality
1927	(Control series)	55	14	25.45	1	1.81	13	23.63
1928	(Control series)	59	13	28.1	3	5.08	10	16.94
1929	(Dehydration series)	27	5	18.52	2	7.4	3	12
	(Control series)	51	12	23.52	3	5.88	9	17.64
1930	(Dehydration series)	118	23	19.49	9	7.6	14	12.8
1931	(Dehydration series)	123	26	21.14	4	3.2	22	17.88
1932	(Dehydration series)	95	13	13.71	1	1.05	12	12.7
Total		528	106		23		83	
	(Dehyhration series)	363	67	18.4	16	4.4	51	14.6
	(Control series)	165	39	23.6	7	4.2	32	20.2

The average yearly total mortality for the series (Fig. 2) shows a difference of more than 11 per cent. between the control group (25.9 per cent.) and those placed on "dehydration" (14.5 per cent.).

As both the control and "dehydration" series show an immediate mortality which is almost identical (4–5 per cent.) for the three-hour group, it seems justifiable to attribute the definite decrease in mortality found in the "dehydration" series to the management and methods of treatment employed.

Surgical decompression was performed as a matter of last resort in eleven cases out of 363. Nine of these patients died (operative mortality 81.8 per cent.) in spite of "dehydration" and decompression. These deaths are included in the final and total mortality figures.

Surgical intervention in this recent series was responsible for less than 0.5 per cent. of the reduction in final mortality, so that this procedure may well be relegated to the specific relief of subdural and epidural hæmorrhage, débridement for compounded wounds, and trephine for drainage of "wet

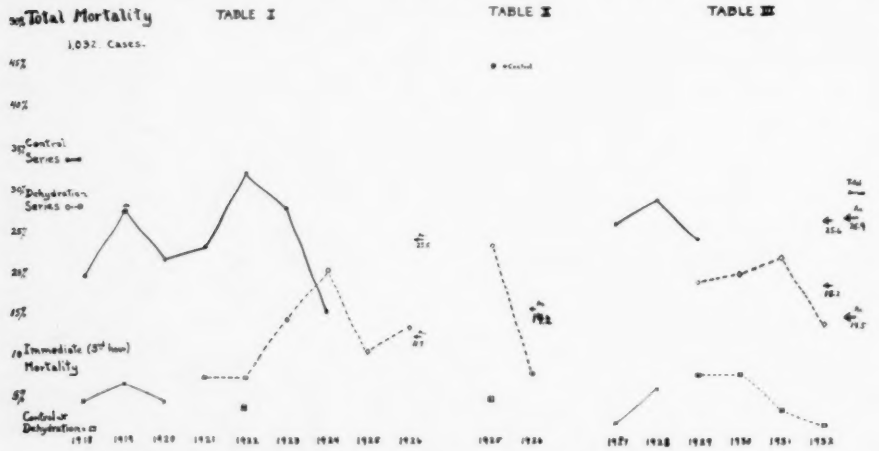


FIG. 2.—Author's Dehydration Series 1921–1933 556 Cases.
Control Series 1918–1929 476 "
Total 1,032 "

brain." Subtemporal decompression undertaken in cases showing bloody cerebrospinal fluid has, in the author's experience, been invariably fatal. The operator usually adds insult to injury when the dura is opened and the congested and swollen brain is allowed to rapidly herniate into the wound. Even in a well-organized neurosurgical clinic equipped to handle such emergencies, the conviction prevails that surgical decompression is justified in acute cerebral injury only as a matter of last resort and that, where physiological methods of decompression fail, operative decompression fails likewise.

GENERAL SURGICAL CONSIDERATIONS.—Frazier,[9] in 1930, pointed out his abandonment of surgical decompression in favor of the more conservative methods of treatment. The practice of subtemporal decompression for relief of increased intracranial pressure, by permitting an herniation of the brain, has been too widely practiced in the past although the results obtained do not justify its use. This type of radical procedure is not to be confused

SERIES D — TABLE IV

Date	Total Cases		Deaths	Per Cent. Total Mortality
1931 1933	(Doctor Genkins' series)*	55	8	14.5
1932 1933	(Doctor Delaney's series)†	26	3	11.5
1934	(Doctor Mock's series)	171	33	19.2
Total		252	44	Average mortality 15.0

NOTE.—Table IV, Series D, includes the reported results of the most recent application of the broad principles of dehydration, in their ultimate refinement, when placed under the direct care and observation of those well trained to manage cerebral trauma, from the moment of admission to the final period of discharge.

* Genkins, M. H.: Report of 55 Cases of Cerebral Trauma, Treated by Dehydration. Survey Submitted November 16, 1933.

† Delaney, W. E.: Management of Head Injuries. Am. Jour. of Surg., vol. 21, p. 3, September, 1933.

with the definitely indicated exploratory craniotomy for a localized or predetermined subdural hæmorrhage, elevation of a deeply depressed bone fragment or control of an accessible bleeding point within the cranial cavity. Such "explorations" may or may not become "decompressions," depending upon the judgment of the operator and the conditions encountered at the time of operation.

As a general rule it may be stated that all cases showing signs of subarachnoid hæmorrhage (bloody spinal fluid) should be spared any surgical intervention as long as possible. If the patient shows definite signs of a subdural hæmorrhage or large depressed fracture, operation after the fifth to seventh day is much to be preferred to early intervention. So long as the patient's general condition can be maintained with safety, the focal problem may be considered as one would a brain tumor; the most favorable results are obtained when the general cerebral pressure, congestion, and œdema have subsided. The bone may then be elevated or the clot removed without difficulty or great risk.

The desirability of delaying all surgical intervention until the acute reaction of the brain has subsided must depend on careful observation of the patient and palliative measures directed toward relief of intracranial pressure in the interval. Here, "dehydration" has been of great benefit.

The one clear-cut indication for prompt surgery after cranial trauma is the presence of a compounded fracture of the skull, where foreign bodies, fragments of bone, hair or dirt may have entered the brain substance. Here the first principle is cleanliness and protection of the brain structures against infection. Débridement and proper repair of the wound should be done as promptly as possible, instituting appropriate drainage if necessary.

FUNDAMENTAL CONSIDERATIONS UNDERLYING THE PRINCIPLES OF DEHYDRATION.—In order to clinically apply the principles of "dehydration" to the many varieties of symptom-complexes which arise following injury to the brain, it is necessary to clearly establish the basis for the manifestations encountered.

The age of the individual, the physical characteristics as to whether they are of the "hydrated" (plump, fat, water-logged) type, or are thin, emaciated, and without surplus water storage, become important factors in modification of treatment.

The appropriate management of a case of cerebral trauma requires a broad concept of the mechanisms involved, so that the most important of these components will be discussed in detail as they may apply to the problem under consideration.

THE CEREBROSPINAL FLUID RESERVOIR.—The physiological function of cerebrospinal fluid has never been clearly established. The presence of from 120 to 130 cubic centimetres (adult) of this clear filtrate of blood-plasma in the subarachnoid and ventricular spaces of the brain plays an important part in the regulation of intracranial pressure by the volume and space which it occupies within the fixed limits of the cranial cavity.

From a physical standpoint it can hardly be considered a "water-bed" or protective cushion for the important nerve-centres. Certain areas of the brain are not included in its field of distribution (Fig. 3), namely, the occipital and temporal lobes, the under-surface of the frontal lobes and the dorso-lateral aspects of the cerebellum. The laws of hydraulics indicate that this "fluid cast" may become a potent factor in the destruction rather than protection of the areas adjacent to its pressure application. The fact that "pressure exerted at any point in a closed fluid system is equally distributed to all points in that system" applies so far as the limits of the craniovertebral cavity is concerned, and this fluid mass serves to register pressure changes uniformly in the cranial or spinal portion of the cavity, if freely communicating.

This fact of recognized pressure transmission is utilized in the procedure of lumbar puncture by establishing existing *intracranial* pressure from the distant lumbar sac. It also serves to establish when the fluid system is interrupted (blocked by spinal tumor or foraminal hernia, as evidenced by the Queckenstedt test and other observations), based upon the ready transmission of pressure by the spinal fluid "cast" from point to point.

The same property also conveys upon the free spinal fluid cast dangerous and destructive possibilities. Spinal compression or concussion may be instantly transmitted to the brain surfaces. Changes in intra-abdominal and intrathoracic pressure may be relayed to the fluid cast by means of the large paravertebral venous sinuses as well as the cerebral dural sinuses, so that coughing, straining, the exertion of labor, and visceral compression, variously affect intracranial pressure. Cerebral function and activity are frequently impaired by prolonged applications of such transmitted disturbances.

FIG. 3A.—Anterior-posterior view showing normal air pathways. Note the presence of air at the vertex in the pacchionian area, the diamond-shaped third ventricle, the aqueduct and upper portion of the fourth ventricle. Both lateral ventricles are normally outlined. Air may be seen just above the corpus callosum. The longitudinal sinus is well shown and the falx seen separating the two hemispheres. (Courtesy, Am. J. Psych., vol. 8, p. 5, March, 1929.)

FIG. 3B.—Lateral view, normal encephalogram. Note the fine air markings following the sulci over the cortex, the slight increase of air at the vertex and normal ventricle. The descending horn is not seen. The cisterna chiasmatis and cisterna pontis are clearly defined. The third ventricle may be vaguely seen and the aqueduct of Sylvius noted. The air markings over the frontal lobe are normal. (Courtesy, Am. J. Psych., vol. 8, p. 5, March, 1929.)

One cannot justifiably ascribe to this fluid the purpose alone of a physically protecting "shock-absorbing" mechanism. Phylogenetically, this fluid system arose at the level of the lower fish and has been carefully retained in the central nervous system plan since the appearance of an outer protecting tube, wall, or bony cavity developed to surround the important nerve-centres.

A closer study of this mechanism seems to indicate a far more important rôle such a volume of fluid may play within the closed confines of the craniovertebral cavity.

When the craniovertebral cavity became a fixed and unyielding boundary for the housing of the brain organ, then some easily mobile and variable *volume* component had to evolve to expand or contract, depending upon the needs of the enclosed organ, in order to permit the high and low tides of cerebral circulation and the possibilities of swellings, tumors, and compensable accidents that might arise in the life cycle of the species. Certain it is that those forms of life which could not adjust the physical needs of the brain organ to such changes perished quickly without the possibility of reproducing their kind.

Spinal fluid arises as a dialysate from blood-plasma (Fremont-Smith[10, 11]) and closely simulates lymph and œdema fluid in its protein content. It is readily restored into the venous channels and large sinuses of the dura. Here according to Weed[12] the pacchionian structures function as large filter beds. Fluid may enter directly into the small veins of the cortex (Dandy[13], Kubie[14]) or be more rapidly passed through the larger areas offered by the pacchionian bodies when emergency readjustment of fluid volume is required. During periods of surgical shock and loss of blood volume the choroid plexus is said to draw freely upon the fluid collection in the ventricles, thus reversing its usual function.

The important fact remains, however, that spinal fluid volume and pressure may be rapidly diminished by withdrawal of this fluid into blood volume, thus not only assisting in the adjustment of volumes in the cranial cavity, but serving also as a source of emergency supply of physiological saline solution when the total blood volume of the body requires temporary replacement (Swift[5]).

In this sense, the spinal fluid reservoir responds, as other interstitial collections of fluid do, to assist in the balance of blood volume, so that adequate blood-pressures may be maintained throughout the body. This body of fluid situated in the most highly protected portions of the individual serves as a "safety vault" or emergency storehouse for water when hæmorrhage, "surgical" shock, and rapid loss of fluid from the skin or bowels require prompt replacement to maintain adequate vascular volume.

This fact is responsible for the fall in the fontanel of the infant when diarrhœa or dehydration occurs. It is the basis for the observations of Weed and McKibben who noted the fall in spinal pressure occurring when intestinal hydragogues were used in animals. It is the basis of purgation and

sweating where so-called toxic substances ("water-intoxication" of Rowntree) are eliminated from the body with clearing of the patients' sensorium and improvement in mental and neurological states. It is the age-old practice of medicine—purgation, bleeding and sweating—all of these measures serve to deplete the spinal fluid reservoir, provide space for a return of better cerebral circulation to the brain, allowing better cerebral function in a crisis.

The effectiveness of the use of hypertonic solutions by bowel or vein depends first upon an adequate subtraction of fluid from blood volume so that appropriate withdrawal of fluid from the body tissue reservoirs will be required. These indirect "dehydrating" methods fail if rapid elimination of water from the body is not obtained, or restriction of liquid intake practiced. Blood volume will not deplete its natural storehouses if other sources of fluid are easily obtainable.

As the principles of "dehydration" are based primarily upon this fundamental concept, it is important that the objective in treatment should constantly be the regulation and control of this compensatory cerebrospinal fluid volume by whatever clinical means now in our possession.

It is obvious that as swelling, hæmorrhage or tumor (clot) occurs within the craniovertebral cavity, the space occupied by these abnormal intruders must be surrendered by some other component. Naturally, we desire to retain the nervous structures and the brain organ intact if possible. We do not wish to sacrifice this brain volume (herniation, decompression, lobectomy) unless forced to do so. The volume of blood within the arteries, capillary bed, and veins must be maintained if cerebral cellular activity is to continue. The brain requires constantly large quantities of oxygen, proper nutrition and elimination of carbon dioxide, if its function is to endure. Where damage or injury has occurred even additional amounts of blood are needed to repair the wounded tissue. The same principles are involved in the repair and retention of tissue viability here as in other body tissues. If pressure and anæmia persist or reach the subvital level, degeneration and softening occur. A decubitus on the back undergoes the same cycle. Clinically we employ heat, massage, and stimulants to encourage a return of local circulation to the skin. The full integrity of circulation must be encouraged if we are to promote repair and prevent tissue death. The first step in the treatment of a decubitus is the removal of the offending cause of pressure so as to permit a return of blood to the anæmic area. In the brain the same principle must be promptly undertaken and constantly maintained as the craniovertebral bony walls not only limit our accessibility to the brain organ, but serve as a relentless barrier against relief from swelling and pressure within. Almost every other organ in the body finds some additional space for swelling, so as to permit continuation of its blood supply without sacrificing its remaining function. The limits of adaptability of an organ or member are determined by the character and integrity of its confining surfaces.

As brain cells experimentally show swelling and chromolysis after ninety seconds of complete anoxæmia, and degenerate completely after four minutes of such a state, it is obvious that cerebral circulatory volume must be maintained at all costs, and to the full need of the organ.

In view of the fact that fluids are incompressible, and that the craniovertebral contents can be divided roughly into: (a) red fluid (arteriovenous blood), (b) intracellular fluid (cells contain from 68–86 per cent. of water), and (c) clear fluid (spinal fluid and interstitial fluid), the volumes of these three components must vary reciprocally if the container does not expand or is not "decompressed" (Fig. 4). Furthermore, the entire brain organ

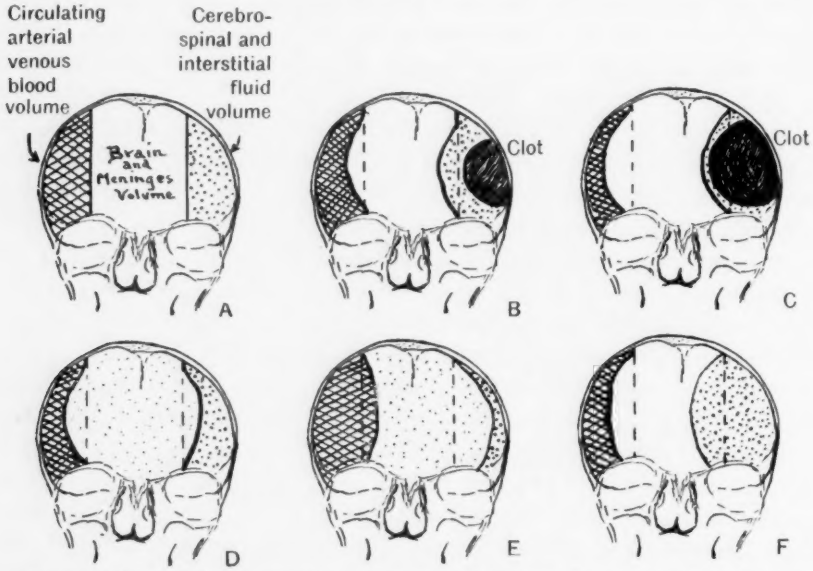


FIG. 4.—Diagrammatic representation of volume relationships within the skull with varying displacements of component volumes in certain types of cerebral trauma. The clinical symptoms are based upon compensation or decompensation between the component volume relationships. The importance of reducing the cerebrospinal fluid component is evident, in order to preserve the vascular and brain volumes, which determine function and the survival of the brain tissue.

A, normal; *B*, compensated volume displacement; *C*, decompensation with compression anæmia; *D*, cerebral œdema with compression anæmia; *E*, cerebral hyperæmia with œdema, increased intracranial pressure; *F*, cerebral atrophy, chronic increased intracranial pressure. (Courtesy S. G. O., vol. 54, p. 362, 1932.)

becomes affected by severe local changes in pressure, as pressure is transmitted equally to all parts by the spinal fluid cast.

We are now faced with a simple problem of physics and hydraulics. It is agreed that the cellular mass (b) should be maintained if possible. It is also obvious that the blood volume (a) must remain at its normal level, or may even require additional space for the hyperæmic phase of repair. Volume (c) is the only relatively unimportant and unnecessary component. Spinal drainage or direct ventricular tap forms a means of removing the free fluid portion of (c) volume (limit approximately 120 cubic centimetres or four ounces). Intravenous glucose or hypertonic solutions favor the depletion of the interstitial fluid component of volume (c). *The combina-*

tion of these measures along with purgation, and the limitation of liquid intake to prevent replacement of the fluid subtracted, constitute the basis of "dehydration" as it applies to various conditions which affect the volume relationships of the craniovertebral cavity.

The control of spinal fluid volume becomes the key to the situation. Subtraction of spinal fluid volume permits needed blood to enter for purposes of repair and nutrition. Readjustments to cerebral volume increases are possible without loss of necessary blood supply within the limits of volume (c). Beyond this point the cranial cavity may be enlarged (decompression) but enlargement of the cavity is of little assistance if the extra space obtained is allowed to be immediately filled by a return of spinal fluid (unrestricted liquid intake, venoclysis, hypodermoclysis, enema, *etc.*). The curtailment of the production of spinal fluid so as to maintain the space secured by drainage or dehydrating measures is of prime importance. Here the experience of the past ten years has shown that adult patients placed upon a total daily intake of twenty ounces (600 cubic centimetres) of liquid and a dry diet (containing not more than twenty ounces of water weight) will not produce sufficient spinal fluid to increase intracranial pressure in the acute traumatic, after the second day of spinal drainage. Only a few cubic centimetres of fluid can be obtained in subsequent spinal taps and frequently a "dry" tap is encountered.

If, however, the patient is placed on thirty-two ounces (1,000 cubic centimetres) of liquid, increased pressure phases will occur and spinal puncture yields as much as thirty to sixty cubic centimetres of fluid with each drainage. Certain variations occur depending on the age of the patient, whether of the fat (hydrated) or thin (dehydrated) type, but in the large majority of cases the principle holds and has been verified in a series of traumatics, as well as chronic idiopathic epileptics.[15]

The clinician must recognize that he is dealing primarily with *volume* relationships and not alone with *pressure. Pressure is only an index of the force of apposition existing between the component volumes and is made possible because of the limits of the container.*

Confusion at once arises when pressure alone is used as an index, as is evidenced when one is confronted with a patient showing a high spinal pressure without the slightest symptoms of cerebral dysfunction, while on the other hand, a patient with low spinal pressure may be stuporous and show abundant neurological signs with only a few of the remaining brain centres intact. In the former instance (a) and (b) volumes have successfully been maintained in spite of the resistance offered by (c). In the latter, (a) volume has yielded its place to the swelling in (b) or the gradual increase in (c).

In the first instance the treatment concerns the question: What has occurred to prevent or alter the proper escape or adjustment in (c) volume? (Tumor, obstruction, chronic adhesions, meningitis, faulty filtration and drainage.) Assistance in the elimination and control of (c) volume must be

undertaken until the fundamental cause of obstruction is corrected, if pressure is to be returned to normal. Production of spinal fluid must be curtailed if possible.

In the case of low pressure and profound cerebral dysfunction, the problem concerns the vascular system perhaps locally or even from the cardiac and general blood-pressure standpoint. Certain it is in the vast majority of cases of this type, that there is a marked œdema of the brain, the cortex is gray-white, the tissues soggy (syncope, eclampsia, uræmia, terminal toxic states, traumatic and alcoholic wet brain, *etc.* Direct inflammation an exception).

The question that presents itself under these conditions is: How can an improved cerebral circulation (speed of blood-flow important) and increase in circulating blood volume be obtained? It is obvious that an increase in blood volume (a) cannot be obtained until space for this is provided by subtraction from (b) or (c) volumes or enlargement of the cranial cavity. It is likewise obvious that there must exist sufficient blood in the general circulation and that this blood must be pumped into the cranial cavity under sufficient pressure to force its way back into the obliterated cortical capillary network. Furthermore, the appropriate supply of oxygen must be carried by the red cells, and proper oxygen tension maintained to permit delivery to the failing nervous centres.

This problem requires not only the judicious use of all measures at our disposal to directly alter (b) and (c) cranial volumes, but an attack on the etiological factor producing the disturbance of general body water metabolism. Proper elimination of fluids through the skin, kidneys and bowels, regulation of the peripheral capillary bed tone, and stabilization of blood-volume, pressure, and red cells, are considerations which will determine the success or failure in the management of such a case. Under these conditions, "dehydration" plays only an important contributory part in the treatment employed.

The fact that blood cannot enter the cranial cavity unless space is allowed for it, is a difficult idea to convey, because the incident is taken for granted and the adjustment is usually so automatic and perfect.

This space normally is yielded within compatible limits depending upon requirements without a change in pressure, by the fluctuating volume of venous blood in the paravertebral spaces and large dural sinuses.

Spinal fluid may be expelled from the cranial cavity so as to make possible changes in volume at many points in the system. Further space may be obtained when "brain mass" increases, by gradual displacement of spinal fluid volume, obliteration of the subarachnoid spaces and distortion of the ventricles. So long as this adjustment can occur, symptoms of "pressure" do not arise. This mechanism is frequently seen in gradual subdural hæmorrhages (with actual displacement of the pineal gland) or the slow growth of a brain tumor with narrowing of a ventricle. If, however, the point is reached where the volume of spinal fluid can no longer yield, or its path-

ways of elimination are blocked, pressure symptoms promptly ensue, with the clash that arises between (b) and (c) volumes for space within the cranial cavity. As cerebral circulatory volume, either local or general, must now yield its space instead of spinal fluid, local or generalized symptoms of cerebral pressure and anæmia arise.

One may usually trace the steps of such a process through the history of headache, vomiting, dullness (weakness, paralysis, focal dysfunction), irritability (delirium and convulsions), stupor, and finally coma.

HEADACHE.—There is a corollary to this mechanism of adjustment for increased volumes which is encountered in cases of cerebrospinal fluid leak, and often in post-lumbar puncture headache. When spinal-fluid volume is constantly lost beyond its regulatory level, (a) and (b) volumes must replace the space. This usually favors a marked hyperæmia and congestion in (a) volume above its necessary levels. As the pain fibres responsible for

FIG. 5.—Mercury injection of the middle and anterior cerebral artery. The basket-like cortical network has collapsed. When the ventricles are distended this network of vessels is tightly stretched. (Courtesy J. A. M. A.)

this sensation are located upon the arterial branches over the surfaces of the brain, as well as a few on the large venous sinuses, *the symptom of headache arises from vascular congestion and traction on the pain network of these over-filled structures.* In order to *reduce* blood volume (a), volume (b) or (c) must increase. Here, forcing of fluid, pituitrin to shut down renal elimination (Fremont-Smith) and raise spinal pressure through body-tissue retention of fluid (force an increase of (c) volume against (a) volume), vasoconstrictors to cut down the volume of (a), ice to the head, and heat to the extremities favor a better blood distribution to the cranial cavity, bringing about the relief of headache as a symptom, by better readjustment of (a) volume. Spinal pressure in these cases is low and the objective must be therefore to introduce sufficient volume in (b) or (c) to offer a higher pressure resistance to (a). As pressure rises and more spinal fluid is produced than lost (a) volume recedes, the symptoms abate, and a more normal relationship occurs. ("Hydration" instead of "dehydration.")

Headache in the great majority of cases, however, is due to increased intracranial pressure, because of an increase in (c) volume or its failure to yield

space required by a growth in (b) or hypertension in (a). Here, although (a) volume may be actually diminished, the subarachnoid spaces are overfilled, the arterial vascular tree is stretched by the distended arachnoidal trabeculæ and the ventricular tension of fluid expands the convex surface of the brain. The entire cortical vascular network becomes taut and pulsating. This pulsative elasticity produces traction on the vascular tree and the pain fibres register the same warning symptoms of headache as they did when the vessels themselves became overdistended with blood from within (Figs. 5 and 6).

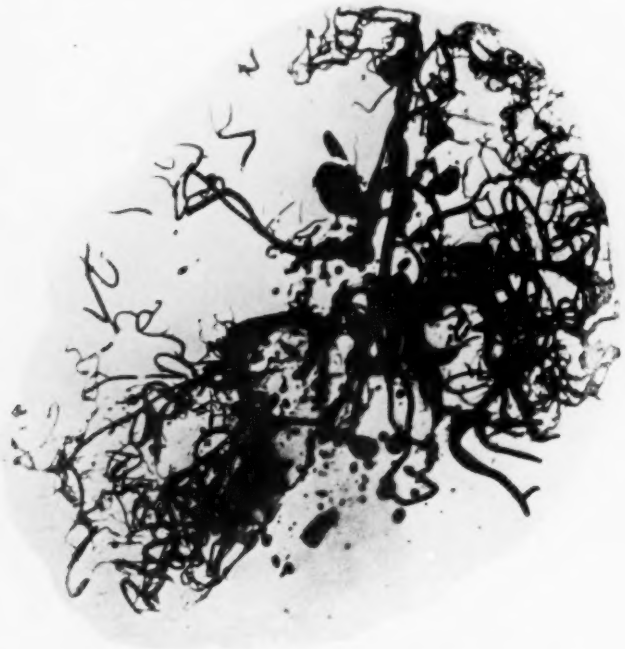


FIG. 6.—Superior view of the brain showing partial distension of the vascular network (X-ray photographs). (Courtesy J. A. M. A., vol. 84, 1927; June 6, 1925.)

This type of pressure headache is immediately relieved by ventricular tap (release of structural tension) because the distended vascular network and cortical brain mass are permitted to relax. Spinal drainage depletes the subarachnoid and ventricular fluid spaces so that the vascular tree is released from its stretched condition. Clinical measures of "dehydration" accomplish the same result in a more gradual manner. Each method has its individual or combined indication as the case may be, but all are directed at the reduction of spinal-fluid volume to relieve the mechanical traction placed on the arterial network from the circle of Willis throughout its branches.

If the objective is to control the symptoms of headache alone, the clinician must not overlook the fact that withdrawal of an appropriate amount of

spinal fluid will adjust the distention factor and bring about the desired relief. However, if spinal-fluid volume is reduced below its ordinary limits, an increase in vascular volume will be encouraged and with hyperæmia there follows headache of the low pressure type to replace the former, and as the patient is scarcely able to detect the difference between these two extremes, the clinician is frequently puzzled because expected relief has not been apparently obtained. "Dehydrating" measures if added under these overwithdrawal conditions only increase the headache. The operator is convinced that as he found evidences of increased pressure at his initial examination, a similar condition has returned. A recheck of spinal pressure should be done in order to reveal which of these headache states prevail, and treatment may then be instituted accordingly. Fortunately, most pressure-headache mechanisms are of the type caused by some obstruction to the proper circulation of spinal fluid, and the reappearance of headache is in reality due to the prompt return of fluid to its excessive state. "Dehydrating" methods are therefore usually most beneficial, and only when excessive require a reversal of application.

Since the limitation of liquid intake has come into clinical use to control the rate of production of spinal fluid, the factors noted above must be more carefully considered. The general rule of "pressure headache" that formerly prevailed now no longer holds. Following lumbar drainage the patient used to be allowed to indulge freely in liquids, again permitting rapid replacement of the fluid withdrawn and a return of pressure. Consequently, the results of treatment were more variable and the measures utilized more heroic.

The symptom of headache, in order to be properly interpreted and treated, must be considered from two standpoints: (1) Stretch on the pain end-organs of the vascular tree, due to overdistention of the vessels (hyperæmia, increase in volume (a)), or (2) stretch on the pain end-organs, due to overdistention of the subarachnoid spaces and the ventricles ("pressure" headache, increase in volume (c)).

Headache of the first type (hyperæmic) may arise from extracranial conditions such as cellulitis of the neck or scalp; paranasal sinus infection, involvement of the tonsils, pharynx and mastoids. Here the cerebral circulation is the unwilling recipient of an increased blood volume designed primarily for the branches of the external carotid artery, but no mechanism of regulation exists at the bifurcation of the common carotid artery to direct the increased amount of blood sent by the heart and required by the infected areas, so that it is alone confined to the external carotid distribution. The internal carotid shares in this increase of blood volume to some degree, and the consequent rise in (a) volume intracranially is frequently associated with headache.

The author has pointed out[16] the existence of these vascular pain fibres on the internal and external carotid arteries and its branches. The symptoms of deep, dull, throbbing, aching pain in the head, as well as the similar

type of pain encountered deep in the face and known as "atypical facial neuralgia" ("lower half headache," Sluder's syndrome) are, in the author's opinion, due to hyperæmia and irritability of the vascular pain fibres. Frequent observations on patients under local anæsthesia indicate that the brain itself is sensitive to a deep, dull, aching pain *only* when the arterial branches are stimulated by faradic current, or the vessels themselves or their attachments are subjected to irritation and traction.

The patient under local anæsthesia is not conscious of such stimulation when applied to the cortex or meninges. The dura itself appears to be insensitive, excepting at the points where traversed by the branches of the meningeal artery. The two lateral sinuses, the superior and inferior sinuses and portions of the tentorium adjacent to the large veins respond to pain stimuli. The patient usually refers the pain deep in the head, behind the eyes; occasionally to the general area of the vascular distribution on the side stimulated.

These vascular pain fibres follow the vessels out of the skull, to their source along the carotids and vertebrals. Some may be found on the jugular vein and in the carotid sheath. They continue down into the upper thorax and find their way into the spinal cord along the sixth, seventh and eighth cervicals, and the first, second, and third thoracic roots (Fig. 7).

The existence of myelinated and unmyelinated nerve fibres on the cerebral arteries has been demonstrated by Hassin.[17] The course and distribution of these vascular pain fibres have been substantiated by Foerster,[18] and more recently by Cobb.[19]

Headache as a symptom, therefore, may be considered as a direct involvement of the vascular pain network by distention and traction, as the most common mechanical cause, although trauma, infection and intrinsic inflammatory disease may also involve them directly. Appropriate measures may be instituted to relieve the condition when the mechanism responsible is definitely established.

Vomiting.—Vomiting may be considered a reaction of defense designed chiefly to protect the individual against: (1) Retention of irritating or poisonous foods; (2) consumption of food or fluid when the gastro-intestinal tract is unable to function or is pathologically obstructed; (3) hydration states usually associated with increased intracranial pressure.

The first two properties of this defense reaction do not concern the subject of intracranial pathology and the specific reactions to toxic drugs; vestibular, ocular responses, psychosensory or emotional manifestations have their own sphere of analysis.

The third consideration of the vomiting reflex has its important part to play in cerebral trauma, as well as other intracranial pathology. Not only is vomiting an indication of the patient's rejection of further food or fluid at a time of cerebral distress, but the mechanism serves the purpose of throwing out from the body a portion of the excess of fluid which threatens the survival of the important nervous centres, thus preparing for the reduction

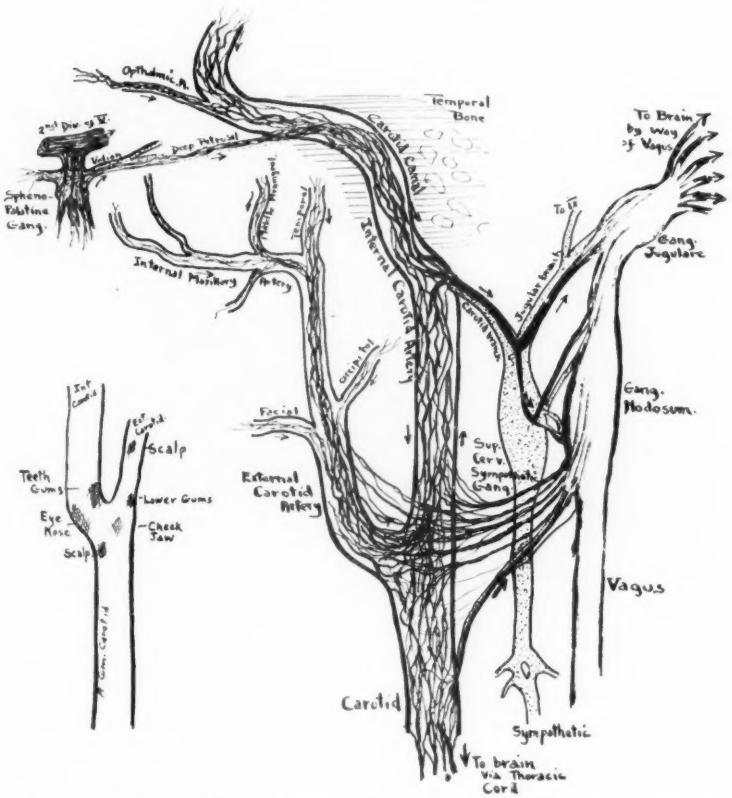


FIG. 7.—Pain network on the vascular tree. These fibres are gathered from the various branches and descend along the carotid arteries in the neck. Some fibres turn back into the vagus while others continue along the jugular and carotid sheath into the thorax entering the lower cervical and upper segments of the thoracic cord (C_5 to T_3). (Courtesy Annals of Otol., Rhinol. and Laryngol., vol. 41, Dec. 4, 1932.)

Arterial Branches Stimulated	Pain Reference
1. Meningea Media	Deep in the eye Temporal region; deep
2. Cerebri Media	Deep in the eye Headache
3. Temporalis Superficialis	Ear Scalp temporal region
4. Maxillaris Interna	Eye Malar region
5. Occipitalis	Scalp occipital region Back of neck
6. Maxillaris Externa	Inner canthus of eye Cheek
7. Lingualis	Tongue Tonsillar region
8. Carotis Externa	Scalp, malar region Gums, teeth, jaws
9. Carotis Interna	Deep in ear Deep in eye Headache
10. Bifurcation	Scalp, ear, nose, teeth Gums, cheek, jaws, tongue

of (c) volume. Where the other important portals of elimination are deficient, such as skin and kidneys, vomiting may arise as an accessory means of fluid elimination from the body.

Although the cerebral vomiting centres have not been definitely localized to a particular area of the brain, it is probable that they lie close to the walls of the third ventricle in the hypothalamic nuclei. The recent work of Fulton and Watts[20] established a precentral cortical zone concerned with peristalsis but no reaction similar to vomiting was obtained by stimulation of this cortical area.

Vomiting may be easily induced in the procedure of encephalography by rapidly changing intracranial pressure through the mechanism of withdrawing spinal fluid and the introduction of air. If, however, pressure is carefully maintained throughout the interchange of fluid and air, vomiting does not occur.

Cerebral vomiting is not always projectile in type, but may be responsible for a considerable loss of fluid over what had recently been ingested. The stomach serves the purpose of elimination of fluid from the blood volume as does the kidney and skin.

If one were to assume that the cerebral centres had developed the mechanism of vomiting, or food and fluid rejection, when the total needs of the storehouses of the body had been exceeded, then many symptom-complexes would be brought into a far more understandable light. For instance, a paradox seems to exist where "hydration" of the brain occurs in conjunction with an obvious dehydration of other body tissues (*viz.*, terminal hydrocephalus, meningitis, paresis). The "hydration" here is in reality an overaccumulation of cerebrospinal fluid and not cerebral œdema. As long as the body hydration protective centres are located within the cranial cavity, it would be logical for them to react to pressure states of this type, as though the entire body were affected by a state of overhydration similar to that existing in the brain.

It is here that many differential diagnostic features arise. If the gastro-intestinal tract as the offender has been carefully ruled out and the signs of hydration are not in evidence elsewhere, the clinician is driven to suspect the brain and look for increased intracranial pressure. Simple general hydration states of the body are frequently overlooked, and excessive ingestion of liquid not checked. Vomiting under this circumstance (plump infants, alcoholics, eclamptics, *etc.*) may be due entirely to water "intoxication" and the cerebral and gastro-intestinal systems be erroneously suspected of pathological involvement.

Fat, hydrated infants and children are more apt to vomit following head trauma than the adolescent or adult. The symptoms of vomiting may be influenced by the general state of water metabolism throughout the body. Its significance must therefore be judged by the age of the patient and the state of the individual's storage reservoirs. It may be a symptom therefore of only slight importance in some (hydrated types) or of profound significance in others (thin, dehydrated types).

Prompt and active purgation with hypertonic salines, along with strict limitation of fluid intake, will usually control the general hydrated type. Initial spinal drainage and appropriate fluid regulation will assist the dehydrated group.

It has been a striking fact that post-traumatic and increased intracranial-pressure cases will tolerate small portions of solid food as soon as consciousness has been reëstablished, whereas liquids are promptly vomited and subsequently all foods are rejected.

Stupor and Aphasia.—A careful neurological examination should be made, with particular reference to the size of the pupils, their reaction to light and the presence of hemianopsia, if this can be demonstrated. Facial weakness should be carefully sought even in semi-stuporous patients. This can be demonstrated usually by pressure upon the supra-orbital nerves.

Aphasia, in contradistinction to stupor, is one of the most important signs to be considered. A patient may give the impression of stupor when he can neither speak nor understand. This may be an important focal sign which is often mistaken for stupor, and in reality the location of the lesion might be determined by this finding alone. If the patient be right-handed the lesion is probably in the left Sylvian area. There may be an associated weakness or paralysis of the right arm and if so aphasia must be carefully considered. The best means of determining the difference between aphasia and stupor is to produce an extremely painful stimulus on the patient and note his reaction. If partly stuporous or wholly unconscious he may rouse sufficiently to make *purposeless* efforts to react in a general way to the pain (groaning, squirming, restlessness). On the other hand, if aphasic, the patient will attempt to remove the painful stimulus in the ordinary way. Thus if severe pressure be made upon the supra-orbital nerve the face may draw up on the side of the pressure (test for facial paralysis), but the patient may also make a definite *purposeful* effort with the unparalyzed hand to remove the painful pressure exerted by the examiner, indicating knowledge of the painful stimulus, its location, and how to prevent it.

When stupor or aphasia is profound the most responsive area to pain will be found in the upper and inner aspect of the thigh, and here, if the folds of the skin are grasped firmly and pinched with force, a marked reaction on the part of the patient is usually forthcoming. If no response can be obtained from this area, the patient may be considered profoundly stuporous. Rectal dilatation at times may be a means of arousing such a case. The test determines the degree of physiological continuity of the cortex, which still remains, and where all efforts fail to rouse the patient, the cerebral injury or pressure may be considered as being extremely widespread.

Restlessness.—The most frequent finding is that the patient shows extreme restlessness and violently resists restraint, so that if cerebral bleeding is present this may be greatly increased and the condition of the patient becomes worse for the need of quiet and relaxation. Here it is important to give sodium luminal, grains 1 to 3 hypodermatically, and large doses of

chloral hydrate and bromide by rectum. An adult dose may be fifteen grains of chloral and thirty grains of bromide by mouth, or if impossible to administer the sedative in this manner, double the dose by rectum. The same dose may be repeated in four to six hours if necessary. Morphine or its derivative should *never* be given unless other sedatives fail, for there usually ensues respiratory difficulty due to intracranial pressure and œdema with additional depressor effect of the narcotic.

Initial Observations.—The neurological examination should also include testing of the reflexes, especially the Hoffmann reflex (snapping the middle fingernail with the hand in mid-pronation. If accompanied by a response of approximation of the index finger and thumb, the sign indicates involvement of the upper motor neuron for the hand centre). The Babinski reflex is extremely important and must be carefully taken, using a variety of degrees of plantar irritation on the outer aspect of the sole. The Oppenheim sign may often be obtained when other signs are absent, and suggests the laterality of the lesion. The tendon reflexes may give a clue if unequal and unilaterally exaggerated, but frequently their entire absence makes these signs unreliable. Clonus is rarely present during the early stages following a head injury. A most important observation when profound stupor is present may be the determination of muscle tone by grasping the patient's wrist and lifting the arms directly upward to their full length, permitting them to fall of their own weight against the sides. On the side of a focal paralysis the extremity will frequently demonstrate a "flail-like" reaction, falling heavily and limply to the bed. The uninvolved extremity will also fall promptly but one may observe the more gradual return of the part to its former position.

The temperature, pulse and respirations should be determined every fifteen minutes, the blood-pressure every half hour and the treatment for shock instituted immediately upon admission by the giving of 50 per cent. glucose solution intravenously. The period of shock should have been passed within the first one or two hours following admission if the patient has been properly treated. The necessary care of the wound, the above neurological observations, the spinal puncture with fluid pressure, and the determination of the character of the fluid now present sufficient evidence to determine the subsequent course of action. This may be considered under three large groupings with occasional overlapping, and consequent modifications of the treatment. Representative cases from each group will be considered in detail, the exceptions and the combinations of treatment depending upon the best judgment of the physician in charge.

It is therefore necessary to outline certain fundamental considerations upon which the basis for the treatment will depend.

The Pulse Rate.—From the standpoint of an acute cerebral injury we may assume that the patient probably had no organic vascular disease prior to the injury, although frequently exceptions will occur. The pulse rate, therefore, must be viewed in the light of its determining factor, as changes

in the pulse rate become important considerations in the progress of the patient.

It must be borne in mind that the vagus control of the pulse rate produces normally approximately eighty beats per minute. If irritation of the vagus centre is present or higher centres influence the vagus, the rate may fall as low as forty and I have observed in one case a rate of thirty-eight, present for a period of twenty-six hours (vagotonic states should be relieved by atropine). It is unusual to find a rate which falls below fifty in the ordinary individual unless heart block has been induced by digitalis, or some disturbance of the auriculoventricular bundle is present within the heart itself. In the post-traumatic, however, when the pulse rate falls to seventy this should be cause for close observation and if it reaches sixty-eight or below the attending physician should search for the cause of this vagus irritation. Bloody spinal fluid, increased intracranial pressure, œdema of the cardiac centre, or subdural hæmorrhage must be considered. Consequently the record of the pulse at fifteen-minute intervals throughout the first forty-eight hours is of extreme value in determining the appearance of complicating factors which require early attention (Fig. 8).

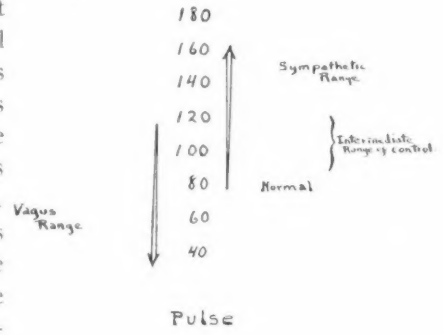


Fig. 8.

On the other hand, should the vagus centre be paralyzed or temporarily lose control of its regulatory action on the heart, a rate of 120 or over will probably ensue. No reliable information, therefore, can be expected of the pulse above 120 in regard to intracranial pressure. If vagus tone has thus been removed one must not overlook the effect of atropine if given during the period of shock as this drug tends to release vagus influences.

A pulse rate over 120 may be considered as the demand of the heart for more fluid volume, and is frequently found in shock. The rate must be considered in the light of sympathetic irritation, restlessness, or loss of circulatory fluid volume and treated accordingly. In the absence of a demonstrable sympathetic irritant (hyperthyroidism, emotion, restlessness, *etc.*), the pulse rate of 130 or above indicates the need for more fluid to replenish blood volume and this may be met by repeating the injection of 50 per cent. glucose solution intravenously with an appropriate small amount of normal saline solution if necessary.

The clinician must have clearly in mind the fact that fluid, though given intravenously, may rapidly leave the circulating blood-stream (Fig. 9) to be deposited in interstitial spaces or given off by perspiration from the skin surfaces. This loss of fluid volume may be directly from the vascular compartment and the circulation is temporarily unable to reclaim this fluid, so that a rising pulse rate indicates the need for further administration of

appropriate solutions to maintain blood volume. As pointed out above, great care should be taken not to introduce fluid that may be rapidly dissipated into the tissues, for fear of precipitating cerebral œdema; hence hypertonic glucose solution should be resorted to in order to assist in reclaiming vascular volume during this period of temporary disturbance.

Much can be determined by the character of the pulse in regard to the peripheral resistance which blood volume is encountering (vasomotor tone,

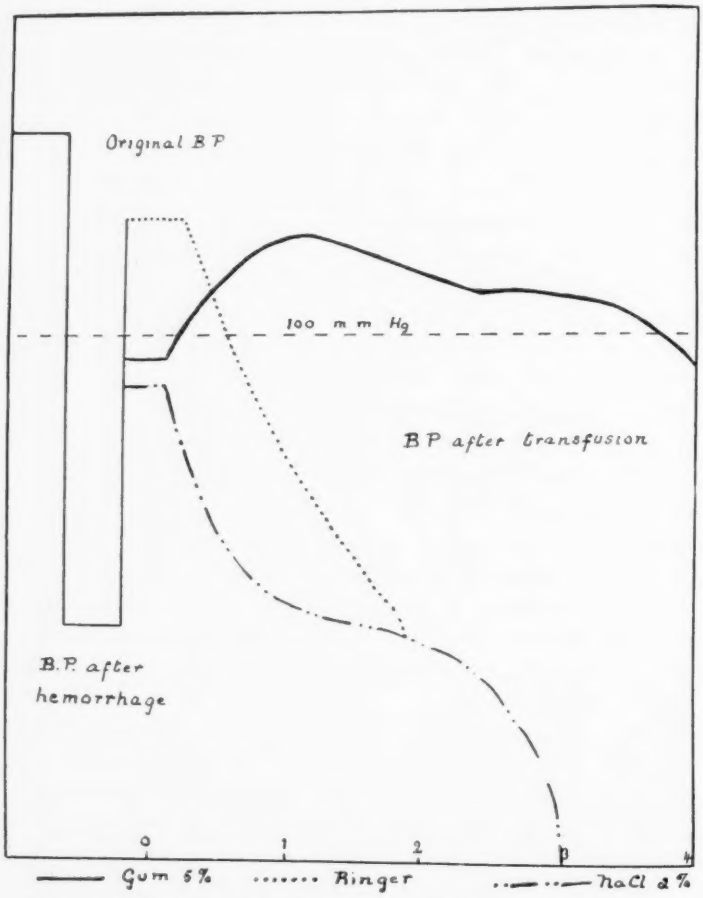


FIG. 9.—Composite curves to show effects on blood-pressure of hæmorrhage, and transfusion with various solutions (N. M. Keith, from Bayliss). The average pressure in the various experiments before and after hæmorrhage is given on the left in a continuous line. The behavior of the pressure after transfusion varied according to the solution used. (Courtesy Macleod, Phys. and Biochem., 6th edit., p. 358. C. V. Mosby & Co.)

capillary bed) in that a rapid, running, thready pulse, easily compressible, signifies either the container of blood volume (vessels) is too large (vasodilatation) or that even with a normal or vasoconstrictor state of the vessels, blood volume is too small to fill the structures. In the former instance vasoconstrictors (pituitrin, ephedrin, ergot) are indicated and not cardiac stimulants. In the latter an increase in blood volume is required (trans-

fusion, glucose, saline). Diastolic-pressure readings help to establish the state of peripheral resistance. In order to relieve the rapid pounding of the heart as well as to raise blood-pressure, maintenance of capillary-bed constriction is important.

The analogy may be drawn to a fire hose without a nozzle. A stream of fluid passing through this hose finds practically no resistance and hence there is no "back pressure." This is similar to the dilated state of the capillaries in the periphery during shock and vasodilatation, the blood running around the circuit without resistance or delay. Returning to the fire hose, if the nozzle be placed upon the end and the outlet thus reduced, "back pressure" becomes sufficient to require a firm fixation of the nozzle by strong hands. The pulsating tortuosity of the hose gives evidence of the fullness of volume working against resistance. This is true of the peripheral capillary bed, which, if properly contracted, produces a rise in diastolic pressure and affords a full resistance for the contracting ventricles of the heart to work against.

The important phase of this physiological consideration is two-fold. In the first place, when diastolic pressure in the peripheral capillary bed has fallen so that it is less than forty millimetres of mercury, oxygen leaves the red blood-cells according to the laws of oxygen dissociation, long before it reaches its intended destination. The outlying cells are thus denied the proper amount of oxygen and cyanosis is usually apparent. With the anoxæmia, increased permeability occurs (Landis[22]) and œdema as well as the rapid loss of function of the tissue cells themselves. One must realize that the periphery is not to be considered only the hands and feet, but is as truly represented in a similar degree by organs close to the heart and in the heart itself. Thus the liver, kidneys, brain and other important structures suffer greatly during periods of vasomotor relaxation and anoxæmia. The object should be to maintain oxygen in not only the vital centres but to the entire organism as death is not alone the failure of a single centre but frequently the overwhelming accumulation of gradual functional loss throughout the structures of the entire body.

The character of the pulse, therefore, becomes important in determining the probable vascular volume and the resistance which the cardiac pump meets in the peripheral capillary bed.

We have come to consider the heart rate in intracranial trauma as being significant of vagus irritation if below 70 and as the "cry of the circulation for more fluid" if the rate be above 120, with allowances for age and evident cardiovascular disease, which must be taken into consideration.

Respirations.—The respiratory rate is of extreme importance as it frequently gives warning in advance of an impending catastrophe. When the rate is above twenty-six, cerebral irritative factors should be suspected and the lumbar puncture usually reveals bloody spinal fluid. Respiratory rates which reach forty indicate a profound cerebral disturbance and are in themselves not so serious as the fact that such rapid breathing produces hyper-

ventilation and the excessive loss of carbon dioxide, which in turn favors alkalosis and œdema. As alkalosis is undesirable because it favors tissue œdema; it has been our custom in profound cases to permit the rebreathing of carbon dioxide by placing a wet towel fashioned in the shape of a cone over the patient's nose and mouth. A stream of oxygen may be added through a small tube into the cone if rebreathing be confined to a closed system. This method not only stimulates deeper respiration but frequently diminishes the rate and may in border-line cases be extremely beneficial.

The most important significance lies in respiratory rates below eighteen. As the respiratory rate diminishes, there is usually associated increased intracranial pressure, which may be relieved by spinal puncture and drainage. Œdema of the respiratory centre may also produce a fall in respiratory rate but this is usually associated with shallow respirations of the Cheyne-Stokes type. Hæmorrhages into the floor of the fourth ventricle frequently produce this type of breathing, as well as hernia of the brain into the foramen magnum and the less recognized condition of hernia of the temporal lobes into the incisura of the tentorium when generalized marked œdema and swelling of the brain are present. If spinal drainage be delayed beyond the forty-eighth hour this type of brain œdema frequently occurs and spinal drainage instituted at this time may be extremely dangerous in that it favors progressive herniation and little fluid can be obtained. Shallow respiratory rates indicate a failing centre.

Respiratory stimulants, such as atropine, caffeine, and carbon dioxide, are indicated when respirations fall below sixteen. Fifty per cent. glucose by vein, or magnesium sulphate by mouth may assist in reducing medullary œdema and thus relieve a respiratory rate which is impaired by pressure or actual œdema. The patient should be turned onto the face and the foot of the bed elevated 45°. Pillows placed under the chest make it possible for satisfactory breathing to be maintained. This measure alone frequently relieves Cheyne-Stokes respirations.

Emergency measures should be introduced when respirations reach ten or twelve per minute as a complete respiratory failure may suddenly occur at this point. One should always be prepared to introduce an intratracheal catheter (woven) so that oxygen may be given directly into the lungs and thus avoid the traumatizing effect of prolonged manual artificial respiration.

In several cases this has been the means of saving the patient's life when sufficient time has not elapsed to deal with the pressure mechanism until after respiratory failure has developed. Sufficient exchange of oxygen and carbon dioxide occurs in the lung when a catheter has been properly placed into the trachea and attached to an oxygen tank to obviate the need of inspiration and expiration. Respirations may spontaneously recur even after a period of an hour or more (seventy-eight hours in one instance) following complete cessation, providing sufficient oxygen has been supplied to the lung bed and circulation maintained. Morphine or its derivatives should never be given where respiratory embarrassment has been indicated by a rate below

eighteen as prompt respiratory failure has been observed under such conditions (even after the use of one-fourth grain of codeine).

A falling respiratory rate in the presence of clear spinal fluid should give the physician anxiety over the possibility of a progressive subdural hæmorrhage. In uncomplicated cases where œdema is the cause of the fall in respiratory rate, magnesium sulphate crystals, one and one-half ounces in water by mouth, or three ounces by rectum will be found efficacious in relieving the respiratory depression.

A fifteen-minute respiratory record should be maintained during the period of serious manifestations as this curve will serve to indicate the load placed on the respiratory centres and frequently warns the clinician of progressive increased intracranial pressure, when the rate is below eighteen, shallow or irregular. Rates above thirty should be considered in terms of hyperventilation or alkalosis. Results of prolonged hyperventilation are to be avoided, as they favor tetany, decerebrate rigidity and general tissue œdema, augmenting the usual pathological signs.

TEMPERATURE.—Temperature is for the most part influenced by the regulation of evaporation of moisture from the skin surfaces. The subnormal temperature noted in shock is probably due to the rapid loss of fluid through the skin onto the body surfaces. It becomes important, therefore, to maintain a dry skin surface to check this source of heat loss and the application of external heat to assist in the body's reëstablishment of this important factor. *The duration of the subnormal temperature,* therefore, may be considered as *an indication of the period of shock* and the time required for readjustment of vasomotor relaxation associated with a leaky skin. In hyperthermia the skin is usually dry and hot with little available moisture for evaporation and hence insufficient radiation. Temperatures rapidly rising as high as 107° and 108° indicate hæmorrhage or œdema *within* the brain substance, usually between the striate region and the medulla. Transitory disturbances of the vasomotor or heat-regulating centres need offer no concern provided temperature is not permitted to go above 103°. Sponging should be introduced when the temperature reaches 103°, and maintained at half-hour intervals, if there is a tendency toward a further rise. This is best accomplished by applying a wet bath towel to the entire exposed body surfaces, using tepid water and leaving the skin wet and exposed, permitting rapid evaporation, meanwhile protecting the patient from any direct draught. It is useless to expect results if the skin is dried after the sponging; it must be kept wet constantly and exposed without coverings. Too frequently the patient is heavily covered with blankets which do not permit proper radiation.

A fall of 1.5° of temperature within ten minutes following such methods of sponging has been noted. Occasional continuous cold colonic irrigations, composed of hypertonic magnesium sulphate solution, may be resorted to when the danger point is exceeded. Rapidly rising temperatures above 105° usually indicate a terminal condition and strongly suggest an intramedullary

hæmorrhage within the brain substance. The temperatures above 107° rapidly destroy the function of the brain cells, if acquired in a short space of time, and do not yield to methods of body-heat reduction. It is therefore important that rapid rises of temperature be checked in their early stages of progress, and imperative that sponging be resorted to when 103° are registered by the patient. The author has used phenacetin in small doses (grains 3) to assist in the production of a moist skin and thus favor a reduction in temperature.

The temperature, therefore, when taken at fifteen-minute intervals may indicate the duration of the period of shock as well as the presence of a deep-seated intramedullary hæmorrhage. Few cases are on record where a patient with an intramedullary hæmorrhage larger than a walnut has survived,

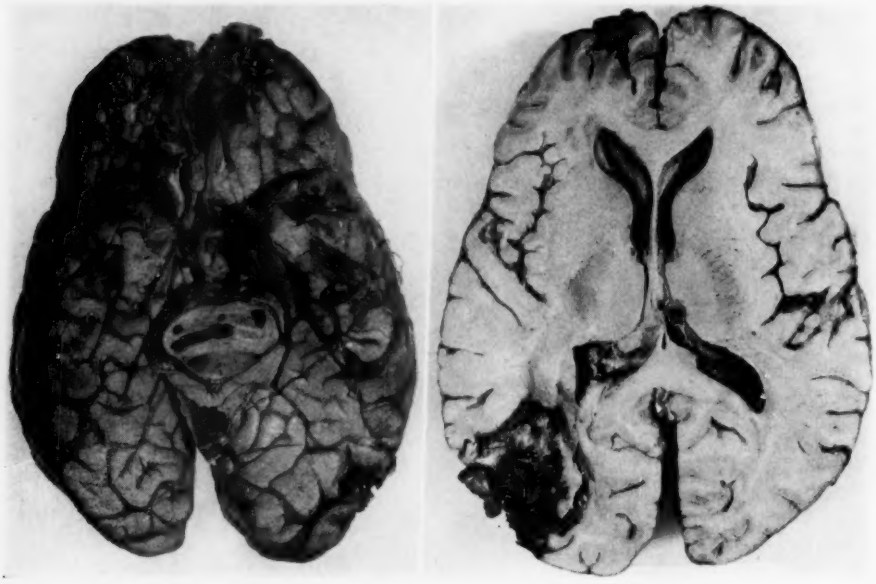


FIG. 10. FIG. 11.

FIGS. 10 and 11.—The effects of contrecoup injury with compound fracture of the left occipital pole with transmission of the force contrecoup, producing extensive laceration of the under-surface of the right frontal lobe as well as the mesial tip of the left frontal lobe. Note the hæmorrhage in the pons with destruction of the vital centres lying in the diagonal of the transmitted force. (Preparation by Dr. N. W. Winkelman.)

whether spontaneous or secondary to trauma. The profound physiological and neuropathological disturbances created by such a lesion are almost invariably fatal (Figs. 10 and 11).

BLOOD-PRESSURE.—Blood-pressure readings in cerebral trauma become the guide and greatest source of reliance to the clinician in the treatment and management of a case. If frequent readings are taken and charted, a curve is obtained which foretells the approaching dangers and indicates the appropriate time for preventive measures. In the author's opinion this record is of more value than any other. It is important that a blood-pressure reading be made upon the patient at the earliest possible moment after admission

and where the patient's condition is serious, due to shock or stupor, these records should be taken at fifteen- or thirty-minute intervals.

The *diastolic pressure* and the *pulse pressure* are the outstanding considerations from the standpoint of survival of the patient as well as proper treatment.

Systolic pressures are of little or no concern as long as they are maintained above 75 or below 200 millimetres mercury. The systolic reading represents the driving force of the heart against the peripheral vascular resistance. The cardiac mechanism in cases of cerebral injury is usually organically uninvolved and as long as there is sufficient pressure to drive the blood around the vascular circuit, there is no need for direct cardiac stimulants (caffeine sodium-benzoate, adrenalin, digitalis), as these only overexert the cardiac muscle without correcting the fundamental disturbance in the peripheral capillary bed.

Diastolic pressure, however, represents the peripheral vasomotor bed and its tone. In reality, diastolic pressure is life itself, although too frequently the physician disregards this important figure. It represents the constant low ebb of vascular circulation in terms of the diameter of the peripheral capillaries, thus as already noted above under the pulse, when the capillaries are widely dilated the blood passes through the larger arterioles without entering the smallest capillaries. As the vast majority of functioning tissue cells are supplied from the capillary meshwork, if life is to be maintained, circulation must reach these tissue cells not only with nurtition values but with oxygen, which must be maintained at an oxygen tension of approximately twenty millimetres mercury. Thus at sixty millimetres mercury (Macleod[21]), blood may be nearly saturated with oxygen, whereas at pressures below fifty millimetres it readily loses oxygen, so at ten millimetres there is complete reduction. When diastolic pressure reaches forty the oxygen dissociation curve has reached a point where oxygen on the red cell is no longer available when it reaches the capillaries, and thus "anoxæmia" may be present even though the red cell passes close to the tissue requiring its normal supply of oxygen. As a shift of the pH to the acid side gives a better utilization of the combined oxygen on the red cell, it will be seen that hyperventilation and alkalosis enhance the degree of anoxæmia by increasing the tendency for hæmoglobin to retain its oxygen even under somewhat favorable pressures. Landis[22] has pointed out that anoxæmia increases permeability and permits transudation of fluid into the capillary interspaces at *four times* the normal rate. Thus œdema will add to the circulatory deficiency, increasing in a vicious cycle the limitation of oxygen to the tissues, without which they cannot carry on their normal physiological function.

In diastolic pressure, therefore, we are dealing with the crux of the situation and this must be maintained above forty millimetres mercury by every effort within our means, as the function of the cells themselves which determines the patient's existence will depend upon this factor alone. The physician's attention should therefore be directed toward contraction of the

peripheral capillary bed in shock and at times of vasomotor relaxation. Increase in diastolic pressure favors more uniform oxygen dissociation, better utilization, and thus maintains the functions of the tissue cells. Due regard must be given to conditions that tend to promote alkalosis and œdema, and corrective measures instituted early.

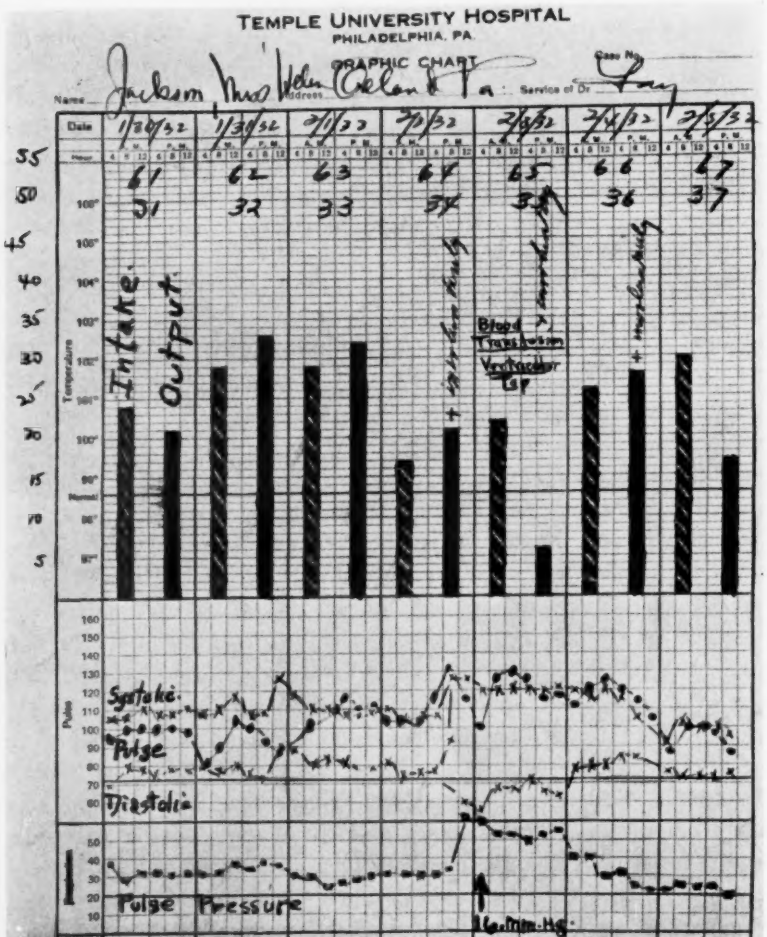


FIG. 12.—(Case I. H. J.).—Hospital record showing acute phase of intracranial pressure with abrupt rise in pulse pressure and fall in diastolic pressure. Note fall in pulse just prior to ventricular tap. Incontinence during the three days of mental obtundity. Improvement after withdrawal of 2½ ounces (75 cc.) under 16 mm. Hg. pressure. Note fluid limitation to 30 ounces (900 cc.) with intake and output record, systolic, diastolic and pulse pressure readings. (Courtesy A. J. Psych., vol. 12, No. 5.)

The cold, cyanotic, clammy extremities clearly tell their story of insufficient oxygen, œdema, capillary permeability and failure of the cells to continue their physiological function. The physician should bear in mind that the periphery is not only the hands and feet, which can easily be observed, but a similar circulatory "periphery" exists in the organs, such as the brain,

liver, kidneys, and heart. It may be expected, therefore, that if diastolic pressure is not maintained, the functions of these organs will soon be diminished and inevitable accumulative tissue-cell death occur. The summation of each added failing integrant brings the final dissolution of the patient.

For this purpose systolic and diastolic pressure readings are carefully maintained throughout the danger period of the patient. These we consider among the most important observations in the entire management of the cerebral trauma cases. By subtracting the diastolic from the systolic pressure, one obtains *pulse pressure*, and by charting the pulse pressure it is evident "which way the wind blows." A rising pulse pressure usually is obtained when diastolic pressure begins to fall and systolic pressure fails to compensate for the deficiency. Occasionally a rapid fall of both diastolic and systolic pressure may give little change in pulse pressure, but this is usually detectable and when diastolic pressure reaches sixty or below, active means for its correction should be employed (Fig. 12). Stimulation of the peripheral vasomotor bed with pituitrin, strychnine, ergot, and ephedrine may be resorted to. Fifty per cent. glucose solution increases blood volume and viscosity and this in turn assists in raising both diastolic and systolic pressure.

The old adage, "If pulse pressure crosses the pulse rate that is the time to decompress," has been supplanted by the more modern method which may be substituted in this statement, *"when the pulse pressure approaches the pulse rate, that is the time to dehydrate."*

By dehydration is meant methods directed toward the relief of intracranial pressure and disturbed tissue fluids, such as ventricular puncture, cisternal or lumbar drainage, hypertonic solutions by mouth, vein or rectum, thus attempting to readjust the proper ratios of the vascular (a) and interstitial (c) compartments. Cerebral œdema, middle-meningeal hæmorrhage and rapidly oncoming intracranial pressure are usually responsible for vasomotor failure. Lesions in the subthalamic area frequently produce incurable vasomotor paralysis. These observations surrounding diastolic pressure and the peripheral vasomotor bed apply chiefly to the period following shock, for during the period of shock itself the vasodilatation and low diastolic pressure noted resemble more closely the toxic peripheral responses similar to those seen in histamine reactions (Dale and Richards[23]) than the central types of vasomotor failure due to local brain anoxæmia.

After the period of shock has disappeared, the diastolic pressure and the pulse pressure become the determining factors in the treatment of the case.

Lumbar Puncture.—This should be performed as soon as possible after the period of shock is over. A twenty-gauge "round-point" Green type of Babcock needle is best. Intracranial pressure should be determined by the use of a mercury manometer (water manometers are frequently inaccurate due to air bubbles, clumsy and breakable).

Bloody Spinal Fluid.—If the spinal fluid is found to be bloody, complete

drainage of all fluid obtainable in the horizontal position is necessary (thirty to seventy cubic centimetres, if possible). Weed[12, 24] and Bagley[25, 26] have clearly shown that the red blood-cells produce intense reaction in the subarachnoid spaces and they tend to stop up the normal arachnoid pathways and filters for elimination of cerebrospinal fluid. Thus they temporarily produce obstruction of the cerebrospinal fluid circulation, chiefly the cortical subarachnoid spaces and pacchionian bodies. The physician is faced with a ten-day period before the red blood-cells in the cerebrospinal fluid are entirely hemolyzed. This means for at least the first seven days following trauma, the cerebrospinal fluid elaborated will not find proper means of escape and intracranial pressure will probably ensue if fluid intake is not carefully controlled. Every effort should therefore be made to remove the red blood-cells by drainage. Sufficient fluid (thirty ounces, adult) should be given by mouth in the twenty-four-hour

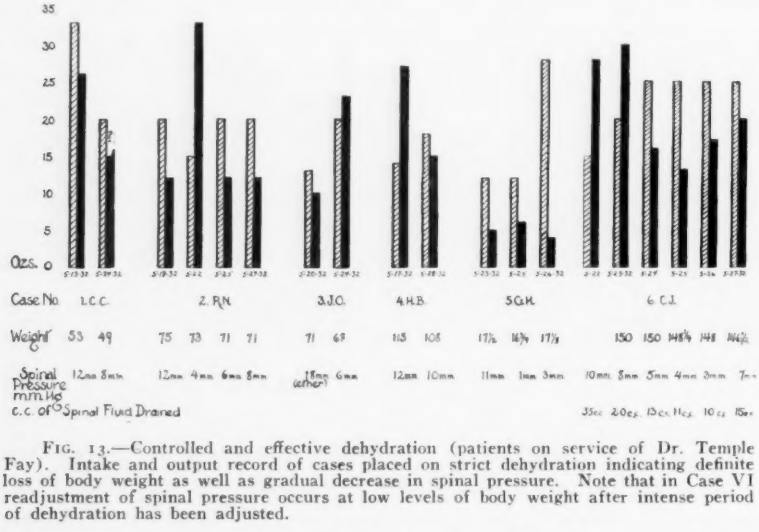

35
30
25
20
15
10
5
Ozs. 0
Case No. 1. C.C.
2. R.N.
3. J.O.
4. H.B.
5. G.K.
6. C.J.
Weight 53 49 75 73 71 71 71 69 113 108 117½ 116¼ 117½ 150 150 148¾ 148 144½
Spinal Pressure mm. Hg 12mm 8mm 12mm 4mm 6mm 8mm 15mm (after) 6mm 12mm 10mm 11mm 1mm 3mm 10mm 8mm 5mm 4mm 3mm 7mm
c.c. of Spinal Fluid Drained 35cc 20cc. 15cc. 11cc. 10cc. 15cc.

FIG. 13.—Controlled and effective dehydration (patients on service of Dr. Temple Fay). Intake and output record of cases placed on strict dehydration indicating definite loss of body weight as well as gradual decrease in spinal pressure. Note that in Case VI readjustment of spinal pressure occurs at low levels of body weight after intense period of dehydration has been adjusted.

period to permit re-accumulation of cerebrospinal fluid for subsequent drainages, but no more, unless other conditions make it imperative (Fig. 13).

Lumbar drainage must be resorted to as often as a rise in pulse pressure and respiratory changes may indicate (fourth or sixth hour if necessary).

The condition may be considered similar to a ten-day loss of bladder function, during which catheterization is required to prevent overdistention of the bladder and disturbance in function of the kidneys. Reëstablishment of the cerebrospinal fluid circulating function is usually possible by the eighth to tenth day following trauma and the need for lumbar punctures and further drainage becomes unnecessary (Fig. 14).

When daily spinal drainage is discontinued, fluids must be further curtailed for a few days. Sedimentation of ten cubic centimetres of the specimen of fluid taken at each lumbar drainage will give a daily record of the rapidity of hemolysis. Daily red cell count of the spinal fluid may also be resorted to.

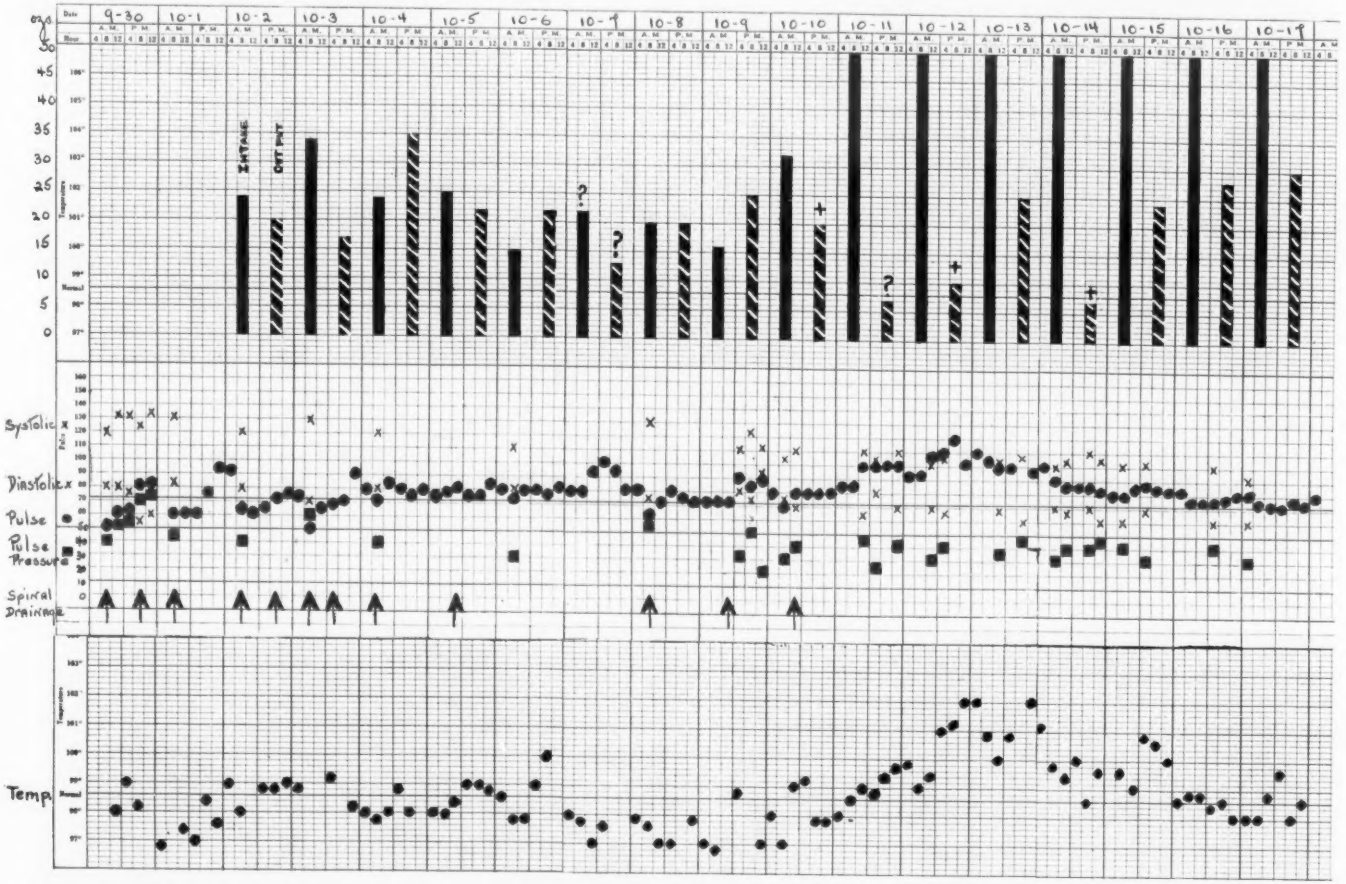


FIG. 14.—Clinical chart indicating the important considerations during the first two weeks following a severe cerebral trauma. Note that no fluids were permitted the patient during the first two days. Black columns represent total intake of fluid. Gray columns total output. Black squares, pulse pressure; gray dots, pulse rate; arrows indicate spinal drainage. On the fourth day, 34 ounces of fluid intake produced crossing of pulse rate and pulse pressure requiring further dehydration. On the seventh day water surreptitiously obtained was followed promptly by rise in pulse pressure and fall in pulse rate, with stupor. Spinal drainage re-introduced. After the tenth day the patient was able to take 50 ounces of fluid without further intracranial pressure disturbance. Note water storage during this period, indicated by low output.

Extensive fracture of the occipital region, respiratory "failure" and intensely bloody spinal fluid (1,300,000 red cells). Note rising pulse pressure and pulse almost crossing for several hours. Glucose and lumbar drainage restored proper relations between pulse pressure and pulse. No fluids for forty-eight hours. Fluid given on third day produced prompt return of pressure with cross of pulse pressure and pulse rate. Active dehydration and drainage restored proper relations and patient out of danger. On seventh day patient obtained large quantity of water surreptitiously and stupor returned in four hours, condition became serious, pulse pressure and pulse again crossed, heroic measures, drainage and dehydration again relieved the crisis and patient recovered. Note after the tenth day fluid may be given up to 50 ounces without effect whereas during the first seven days daily intake of 30 ounces was poorly tolerated. Note also the high temperature during the first seven days.

Clear Spinal Fluid.—If clear fluid is obtained at the first lumbar puncture and the pressure reading at the time carefully taken, the problem becomes one of management of cerebrospinal pressure with or without drainage. Prompt reduction of intracranial pressure may be accomplished by spinal drainage when symptoms require it. It should be resorted to if necessary. Control of fluid intake with judicious use of glucose and magnesium sulphate have been found entirely adequate in such cases. It is at once evident that this means of "decompression" is far more effective and desirable than the operative methods used heretofore and gives better results without leaving a permanent cranial defect. "Decompressions" have been entirely abandoned by Frazier and many others and in the few instances where surgery is necessary, "exploration" (for clot or foreign body) has taken their place.

As the volume of cerebrospinal fluid is largely dependent upon the amount of fluid dialyzed from the blood-stream, which in turn is dependent upon stored fluid in other areas, or quantities of fluid given the patient by mouth, this latter source of fluid must be strictly limited so as to prevent overproduction. Repeated spinal punctures may be resorted to if fluids have been given in excess. It is useless to remove spinal fluid for the purpose of reduction of intracranial pressure only to immediately refill the cerebrospinal fluid spaces by permitting free intake of fluid on the part of the patient. A prompt return of stupor and serious symptoms even on the seventh day has been noted (Fig. 14) following the free unrestricted ingestion of liquids.

The author has established the fact that if liquids are restricted to the minimum (sixteen to twenty ounces per day, adult) little or no excess of spinal fluid occurs (Fig. 13). Ingested liquids above this level yield varying daily amounts of spinal fluid.

Where patients showing clear spinal fluid have been placed upon this allotment there has been no need of further lumbar puncture and symptoms of stupor, headache, vomiting and pressure are absent as long as the proper balance of liquid intake is maintained.

The prompt recovery of the patient from dullness and stupor with the maintenance of an asymptomatic state by proper intracranial pressure and volume regulation is in the author's opinion responsible for the remarkable absence of post-traumatic symptoms in this "dehydration" series and the early economic readjustment of the patient to his former mental levels and physical activity.

On the eighth to tenth day following the injury these patients are gradually allowed more fluid until an intake of thirty-two ounces is reached. They are discharged from the hospital when they are able to measure and regulate their fluids and are taught the basis of the "dry" diet. They are required to follow this fluid and dietary restriction for three months, after which either habits of moderation are formed or they avoid voluntarily former excesses because of the post-traumatic symptoms of dullness, headache, loss of attention and memory, ambition and concentration which arise from hydration states. Once the patients have experienced relief of these symptoms following cerebral

trauma they will not tolerate their return. In cases where strict limitation has not been practiced their discharge from the hospital before complete recovery occurs only dooms them to a chronic state of disability, not sick enough to be hospitalized and not well enough to work. The lack of instruction and post-traumatic supervision permits them to carry on indiscriminate consumption of food and fluid at home without the possibility of experiencing prolonged freedom from their symptoms so that these indiscretions would be voluntarily avoided.

The need for early and if necessary repeated lumbar puncture becomes of as much importance for the correction of immediate cerebral symptoms as it does the control of the chronic post-traumatic phase. The necessity for this procedure may depend entirely on the physician's management of the fluid intake or the patient's continued lack of coöperation.

Since careful regulation of liquid intake has been found to be of such importance, those cases presenting bloody spinal fluid and consequently requiring thirty ounces of intake to insure daily spinal drainage must be shifted from this level of fluid on the sixth to tenth day when xanthochromia indicates lumbar puncture is no longer necessary. At the time of the last drainage liquid intake is cut to twenty ounces for at least two days and then gradually raised to thirty-two ounces, after which the patient may be discharged with the same restrictions and even more careful supervision than the former clear spinal fluid group.

Where subarachnoid bleeding persists and spinal fluid shows no signs of decrease in the red cell count or sedimentation tests after the third day, two to forty cubic centimetres of air may be introduced into the spinal canal in small quantities (following the removal of at least the same quantity or a greater quantity of spinal fluid—procedure controlled by intermittent spinal pressure readings by manometer as in encephalography).

This manœuvre usually promptly controls the free subarachnoid bleeding and in the author's experience has proved highly beneficial. In one remarkable instance (Medico-Chi Hospital, 1924) the red cell count in the spinal fluid on the fifth day equalled the blood count of the patient (1,500,000), so persistent was the bleeding. Prompt recovery followed injection of air and the patient seen nine years later was normally engaged in her former duties as charwoman in a rooming house.

The arguments against lumbar puncture and spinal drainage (see Mock's[7] Survey) in the cerebral traumatic are primarily based on the idea that an increase in the cerebral hæmorrhage may be promoted. All the evidence is to the contrary with the exception of one group. The neurosurgeon has long recognized that when bleeding occurs in the subarachnoid spaces (ventricles, cisternæ, spinal canal) during operative intervention, he must remove the free fluid from about the bleeding point in order to promote clotting. A muscle graft or dry piece of cotton serves to hasten coagulation. As spinal fluid continually dilutes the blood, either the zone about the bleeder must be filled with blood sufficient to permit clotting, or spinal fluid withdrawn from

the area so that tissue surfaces may approximate one to the other or whole blood accumulate without interference.

Rupture of a large vessel (aneurism) either in the subarachnoid space or in the substance of the brain is almost invariably fatal. The spinal fluid, where bleeding of this type reaches the subarachnoid space, resembles almost pure blood and it cannot be denied that spinal drainage under these conditions may hasten the patient's demise. As these patients invariably die with or without lumbar puncture (unless a surgeon is fortunate enough to reach and ligate the vessel in time), those critics of lumbar puncture would use this argument (which applies to a relatively few cases) to deny all others the benefits of reduced spinal pressure, prompt clotting of the usual subarachnoid bleeders, return of necessary blood circulation to uninvolved areas of the brain and the preservation of the vital and gnostic centres required for adequate recovery. The final mortality figures of 13.8 per cent. in this series where lumbar puncture has been practiced and spinal drainage maintained as a routine in such cases, clearly refutes the arguments against its use. Until the "do nothings" of the profession are able to demonstrate results that even approximate these figures the burden of proof rests upon them to justify their neglect of so important a procedure for the good of their patients. Irrespective of the mortality rate the results noted in the post-traumatic group alone in this series with the astonishing preservation of intellectual faculties, clearly establishes the principles of the procedure as not only justifiable but absolutely necessary.

There are those that point out the danger of "foramenal hernia" with sudden respiratory failure, and ascribe this to the effects of lumbar puncture with drainage. In a certain sense this argument is justifiable, but entirely dependent upon the mechanics of the cerebral structures. If the ventricles are not freely communicating with the basal cistern (tumor, occlusion, mass brain œdema), then withdrawal of fluid from about the base favors movement of the brain structures down into the incisura of the tentorium or the foramen magnum. As occlusion by clot in the third or fourth ventricle or aqueduct of Sylvius is *extremely* rare, such a mechanism does not present itself immediately in cerebral trauma.

If, however, the clinician has pursued the course of "do nothing" or adopted purely palliative means during the first twenty-four to forty-eight hours following the trauma allowing a progressive brain œdema to occur with swelling of the cerebral mass and obliteration of the fluid spaces, then foramenal hernia may indeed be a possible sequel to lumbar puncture and spinal drainage. The results should not be blamed upon the procedure, but upon the critical judgment of the physician in charge.

If early spinal drainage and a return of cerebral circulation have been instituted from the first, with appropriate care as to blood-pressure, blood volume and fluid balance of the body, such a cerebral state rarely occurs. If after all measures have failed, the lumbar puncture alone cannot be held entirely responsible.

To undertake spinal drainage late and only when forced to do so is to court disaster. If the principles underlying the procedure are admitted, then there should be no compromise in their proper application. The frequency with which such œdema complications arise in the untreated cases must be admitted, and for those who insist upon pursuing the "do-nothing" policy, the "in God we Trust" and the "it's all in the deck" attitude, it would be well indeed to avoid lumbar drainages as their mortality is already too high, and the injudicious use of inadequate spinal puncture can only further add to results which Mock, Morrow and Shannon[7] have shown to exist in the series where the principles of dehydration are not followed out.

In stuporous patients, delayed use of spinal puncture or drainage is always dangerous and other measures (ventricular tap, wide decompression, intensive "dehydration") may have to be resorted to, with the greatest amount of caution and the highest degree of risk.

Blood Volume.—Blood volume actually holds the key to the entire problem of treatment and survival in cerebral trauma cases, as it does in most others.

As spinal fluid volume arises primarily from blood volume, these two important components of the cranial cavity are complementary and changes in either affect the other reciprocally. Thus, if we wish to reduce cerebrospinal fluid and pressure we may employ the method of Weed by introducing hydragogues into the intestinal tract that draw fluid rapidly away from the circulating blood volume. Such a rapid loss of fluid into the intestinal tract and the vigorous diarrhœa which follows requires prompt replacement of fluid from some source back into blood volume, or serious circulatory deficiency may result. Subtraction of free fluid from the cerebrospinal fluid reservoir as well as from other available tissue reservoirs promptly occurs in order to stabilize blood volume, and the desired effect on intracranial pressure may thus be slowly obtained.

Bleeding, purgation, and sweating have, in common, the property of diminishing blood volume, which in turn may be beneficial to the cerebral centres, in that free fluid volume (c) is drawn upon to replenish the loss from the vascular volume. As spinal fluid volume falls (low tide of fluid), there is space permitted for an increase in the blood volume to the brain and with this possibility (high tide of blood) better oxygenation and nutrition to the cerebral cells with consequent improvement in function.

Probably the accepted beneficial results noted from these age-old procedures have been due primarily to the better adjustment of this cerebral mechanism rather than the elimination of a mythical "toxine," unless the condition of "water intoxication" (Rowntree) be recognized as the real "toxic" agent.

Blood volume enters into the problem from many angles. The period of shock ("surgical shock") which follows severe head trauma gives rise to a series of symptoms which are all primarily due to sudden alteration of blood volume.

In "shock," fluid rapidly leaves the vessels to pass out into the tissue spaces (subcutaneous tissues, cranial and visceral cavities); much fluid is lost onto the skin surfaces (clammy extremities and surfaces, cold because of rapid evaporation and consequently subnormal temperature due to loss of body heat). The pulse becomes rapid as the heart must increase its rate (if its available supply of blood becomes less) so as to fill the arterial tree and maintain adequate blood-pressure. As blood volume becomes insufficient, and the capillary bed dilates (anoxæmia, local vasodilator responses due to histamine-like substances, central vasomotor failure), the pulse becomes weaker and necessarily more rapid; diastolic pressure eventually can no longer be maintained, falls, and pulse pressure rises in consequence.

The symptoms of so-called "surgical shock" (not to be confused with emotional and other types) (Macleod[21]) are those of: (1) Cold, clammy extremities. (2) Subnormal temperature. (3) Rapid, thready pulse. (4) Fall in blood-pressure (especially diastolic below sixty millimetres mercury). (5) Rising respiratory rate (secondary changes in gas dissociation, anoxæmia).

The successful treatment of this condition concerns blood volume alone.

Attempts should be made to: (a) Prevent further loss of fluids from the skin (atropine, warm, dry clothing, heat to restore body loss and counteract effects of evaporation). (b) Restore lost blood volume (saline infusion, transfusion of blood, 50 per cent. glucose or a hypertonic solution by vein to reclaim available fluid from tissues and from body reservoirs). (c) Shrink the size of the vascular bed to fit the blood volume that remains. (Vasoconstrictor drugs.) This allows a rise in blood-pressure, slows the heart rate by providing more blood return to the venæ cavæ and produces a resistance to work against.

The appropriate yielding of these symptoms to treatment depends upon many factors.

The clinician is frequently misled into a false sense of security when a uniform program of treatment is adopted. It is true that the routine treatment may fit the majority of cases, but a patient may be lost who might otherwise be saved, or another receive too rigorous treatment, if each case is not weighed on its own merits. The success of treatment depends upon how much fluid was lost; whether the storage reservoirs are full (hydrated fat types) or scarcely available (thin, emaciated types, old people, *etc.*); how long the state of shock has existed, and how much additional influence the various organs of the body have to play because of complicating pathological states due to chronic disease.

The saline solution introduced into the vein, to refill blood volume, may not remain in the vessels more than thirty minutes to two hours. The original state of shock and depletion may return so promptly that no relief is clinically apparent (Fig. 9).

Much depends upon whether the portals of loss have been closed, or the fluid introduced is made more retainable to the vessels by the addition of gum acacia or 50 per cent. glucose solution.

From the standpoint of head trauma, it is obvious that to treat the period of shock by introducing large quantities of physiological saline solution alone, is but to favor subsequently a rapid cerebral œdema. This additional fluid will serve to increase the cerebral anæmia by overfilling the cerebrospinal fluid reservoir. In the presence of a low blood-pressure (consequent anoxæmia), an excessive amount of fluid finds its way without opposition into the cerebral fluid spaces, besides that which locally arises from the cerebral injury *per se*. When general circulation and blood-pressure have been reëstablished under the method of large intravenous injections of saline, the patient usually fails to regain consciousness after the period of shock, because the available space necessary for the return of blood to the cerebral structures has been temporarily occupied by this free fluid transudate. The resultant struggle for this important space is a clash between (a) and (c) volumes at the expense of (b). Increased intracranial pressure ensues and if the œdema is not rectified, the patient continues unconscious over a long period of time, or the "vital" centres fail, and death supervenes. Too frequently in the past, the patient has been saved from "shock" by large infusions of saline solution only to succumb later to intracranial pressure or œdema induced by this method.

For this reason, cerebral trauma cases require special adaptation of the treatment for shock. If large quantities of saline solution (500–1,500 cubic centimetres) are *required* to combat the phase of shock, then adequate spinal drainage (twenty to sixty cubic centimetres), must follow promptly with the return of blood-pressure to satisfactory levels. Such drainage must be repeated on the second or fourth hour, when pulse pressure rises to fifty or above, unless symptomatic improvement from the cerebral centres has been obtained by the initial measures.

In the majority of cases a small amount of saline solution (100–300 cubic centimetres) *plus* fifty cubic centimetres of fifty per cent. glucose solution (adult dose) serves to restore blood volume temporarily and this dose may be repeated promptly in part or in whole later on, if found to be insufficient. "Better safe than sorry" applies particularly to this period of treatment.

As the objective in the treatment of shock is to restore blood volume to its adequate levels (improve blood-pressure and general circulation) the glucose tends to make the vascular contents hypertonic and draws fluid from the tissue reservoirs and spaces back into blood volume. This not only assists in the desired clinical direction of improvement, but it *prevents temporarily further fluid loss into the tissues and reservoirs* and thus checks cerebral œdema. Of most importance, the cerebrospinal fluid reservoir is prevented from overfilling and frequently may actually be depleted to some degree. As blood-pressure rises by this reversal in the flow of fluid back into the vessels again, the blood circulation is permitted to return to the cerebral structures again because (c) volume is diminishing as (a) volume rises.

The proper manipulation therefore of blood volume during the period of shock in the cerebral trauma group must take into consideration the subsequent problems that will arise concerning intracranial pressure and œdema.

As a general rule, where patients are thin, old, or emaciated, larger quantities of saline must be given, as it is evident that glucose will find little free tissue fluid to draw upon. On the other hand, the fat, hydrated, plump, or alcoholic types may be given glucose alone, and this procedure repeated to become effectual, requiring the patient to utilize his own tissue fluids to replenish blood volume.

Spinal drainage in this hydrated group is almost always necessary in that the movement of fluid from one tissue reservoir to another will tend to cancel the desired result in the cerebrospinal fluid reservoir. After the initial period of shock is over (return of temperature to normal, restoration of blood-pressure) in this hydrated group, it is often necessary to deliberately deplete blood volume again (physiological shock) by giving hypertonic saline (magnesium sulphate) by mouth, (one and one-half ounces of crystals in six ounces of water) or double this dose by rectum. This draws fluid rapidly away from blood volume again and consequently precipitates a mild state of "shock" (rise in pulse rate). If now 50 per cent. glucose is introduced into a vein, blood volume is required to withdraw further fluid from the body reservoirs, and a control of the hydrated type can thus be obtained.

It is of course obvious in this hydrated group that no additional liquids should be permitted the patient by mouth, vein or rectum, if this method is resorted to. A judicious use of the measures at the disposal of the clinician for regulating blood volume, and secondarily controlling cerebrospinal fluid volume, will determine the results which may be expected. To give magnesium sulphate during the period of shock would be to court disaster, as a further loss of blood volume at a critical time would ensue. To give 50 per cent. glucose solution, intravenously, at a time when blood volume had returned to its full state, is only to precipitate an increase of intracranial pressure, because fluid may be forced back into the tissues.

As there exists at the present time a widespread tendency to use hypertonic glucose solution indiscriminately, with the belief that it contains some magic property in these cases, a clear understanding of its true value should be obtained.

We must return to blood volume and its properties for this consideration. It is accepted that blood volume is one of the most "fixed" relationships of the body. Welcher found it to be 7.2 per cent. to 7.7 per cent. of body weight. Keith, Rowntree and Geraghty place blood volume as representing from 5 per cent. to 8.8 per cent of body weight. The accepted constancy of the red cell count around five millions, as normal for all ages, indicates the uniformity of dilution in the blood mass and consequently a suggestive index of its volume. Macleod states, "The newer methods have shown that the volume of the circulating fluid (blood) is maintained *fairly constant in spite of influences tending to alter it.* The body accomplishes this by drawing upon the reserve fluid in the tissues and by varying the rate of water excretion."

There are five general conditions under which blood volume may be pathologically altered: (1) Alteration of cellular content (polycythæmia,

chlorosis, and the anæmias). (2) Emaciating and "dehydrating" states (asiatic cholera, *etc.*).* (3) Direct loss (severe hæmorrhage).* (4) Pregnancy (increased) obesity (decreased). (5) Shock (Dale-Richards type, "Histamine Shock," "Surgical Shock" with rapid loss of fluid into tissues).*

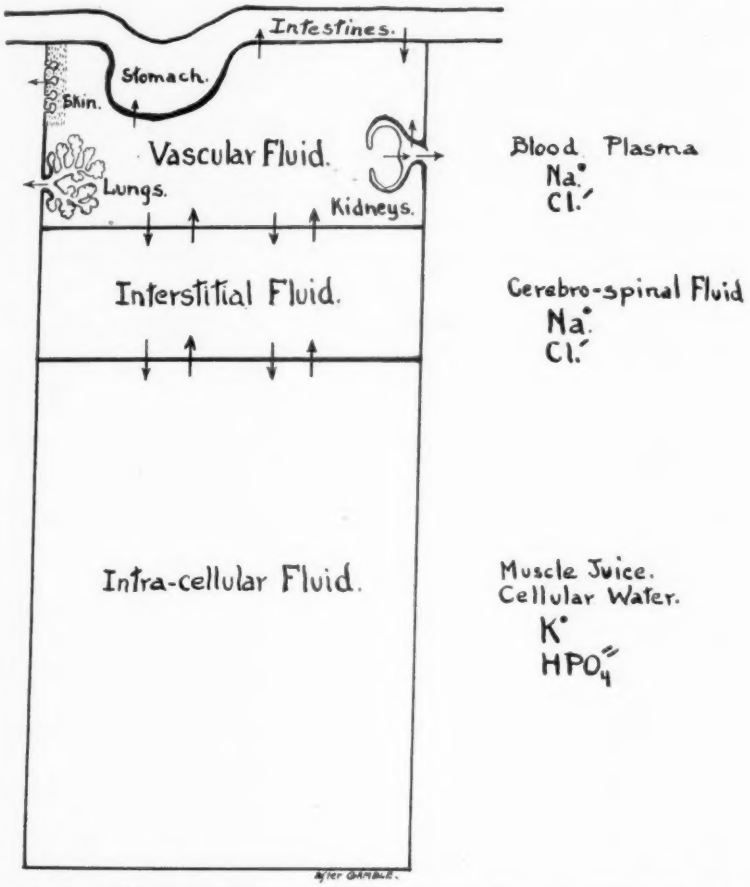


FIG. 15.—Diagrammatic representation of the body fluid compartments (modified after Gamble) showing the directional movement of fluid after entering the gastro-intestinal tract. As blood volume (vascular fluid compartment) tends to remain fixed by means of excretion through its four portals of elimination, or by storage in the interstitial compartment, the proper clinical manipulation of these variables forms the basis of successful treatment. Cerebrospinal fluid represents the largest single interstitial reservoir. Fluid interchange between the vascular and interstitial compartments is facilitated by the fact that both are dependent upon the fixed base Na. for retention, whereas intracellular fluid is maintained by the fixed base K. and exchanges are not reciprocal. Hydration states concern the interstitial fluid compartment and yield to measures of dehydration.

Intracellular œdema on the other hand represents fluid that has become fixed by altered cell metabolism and cannot be reclaimed by practical clinical measures now at our disposal.

Restriction of fluid intake and forced elimination demands that blood volume draw upon the interstitial reservoirs in order to maintain its integrity. (Courtesy J. of Nerv. & Ment. Dis., vol. 71, No. 5, May, 1930.)

In view of the fact that (excepting for the above-noted conditions) blood volume tends to remain unaltered under almost all other circumstances, it seems obvious, therefore, that if blood volume is "normal" the addition of 50

* (2), (3) and (5) intimately concern the problem of trauma.

per cent. glucose solution, in order to draw tissue fluid into blood volume, cannot accomplish this purpose until an equal quantity of fluid has been simultaneously excreted from the blood volume. This must be accomplished through the four normal portals: kidney, skin, bowels or breath. Without medical assistance this process is slow. Glucose in the presence of full blood volume passes out of the blood-stream into the tissues where it is stored and burned. The kidneys rapidly eliminate the remainder. The fluid now tends to pass back into the tissues as the concentration of glucose in the tissues may eventually be higher there than in the blood (due to renal depletion). If the patient is permitted fluids by mouth, skin, or rectum, then repeated doses of glucose in the presence of "Normal" blood volume will promote cellular and tissue œdema and augment an intracranial pressure state that was intended to be diminished. Gamble, Ross and Tisdall,[27, 28] have pointed out that cellular water storage and increase in water retention of the tissues may be due to carbohydrate and glucose metabolism (Fig. 15).

If hypertonic glucose is to be used as a cerebral "dehydrating" agent, space must be provided in blood volume for the tissue fluid that is to be withdrawn. Purgation, sweating, bleeding, shock, increased kidney output, all offer means of depleting blood volume in order that glucose may be truly effectual. Each of these measures has its special indication and contra-indication. Purgation and increased renal elimination are more easily controllable, and their use more common.

In view of the tendency for blood volume to rapidly return to a normal level if possible, 50 per cent. glucose, if given in the period of shock, is ideal, as blood volume at that time is depleted and needs tissue fluid. After the period of shock has passed, hypertonic glucose solution should not be given *unless preceded by some measure to actively reduce blood volume.*

The first dose of glucose given as soon as the patient reaches the accident ward has been found highly beneficial. The second dose should be given only if indicated, to supplement the first. The third dose requires proper preparation of blood volume for its effectiveness and has been found to be rarely required in the author's experience.

Glucose is one of the most important "dehydrating" adjuncts if properly used where its osmotic pressure effects can be most beneficial. It may become a boomerang if used with careless disregard by those who adopt the slogan, "when in doubt, shoot a little glucose."

Summary of Treatment and Routine

I. Upon Admission of Patient to Accident Ward: (a) Immediate temperature, pulse, respiration and blood-pressure determinations. (b) Temporary dressings to wound—control of hæmorrhage. (*No detailed wound repair.*) (c) Intravenous fifty cubic centimetres (adult dose) of 50 per cent. glucose solution. (If *necessary* give in addition 100–300 cubic centimetres saline solution to combat severe blood-volume loss of fluid.) (d) Shock cabinet, warm, dry blankets, heat to body surfaces, elevate foot of bed 45°. (e)

Appropriate medication—atropine, pituitrin, ephedrin, ergot, strychnine. (f) Sedatives. Chloral hydrate (grs. xv.), sodium bromide (grs. xxx) by mouth. Double dose if given by rectum. Sodium luminal, grs. i to iii by hypo. Repeat above as indicated. q. 4th hour. (*Avoid morphine and its derivatives,* if possible.) (g) Physical and neurological examination as brief as possible.

II. Period of Shock.—The signs of *subnormal temperature,* cold clammy extremities, low diastolic pressure (usually below sixty millimetres mercury) rapid, thready pulse (usually above 120) increased respiratory rate and abnormal pulse pressure (40 normal) indicate the presence of shock.

The treatment of shock takes precedent over every other consideration (few exceptions) and must be brought promptly under control.

Fig. 16. Fig. 17.

Figs. 16 and 17.—Unilateral contrecoup hæmorrhage from trauma in the parieto-occipital area. Note involvement of the under surface of the left frontal lobe and tip of the temporal lobe with bilateral diffuse subarachnoid hæmorrhage; swollen convolutions and generalized cerebral œdema on the left. (Preparation by Dr. N. W. Winkelman.)

Suture of the wounds, spinal puncture, detailed neurological examination, X-ray examination, or unnecessary movement of the patient should *never* be attempted until adequate recovery from shock has been established. Occasionally, the patient's distress will require immediate lumbar puncture. This should follow the glucose administration and other medication to fortify the additional loss of fluid from lumbar drainage.

The period of shock may be considered over when the *temperature* of the patient returns to normal or above. Temperature, pulse, respiratory and blood-pressure recorded every fifteen minutes. Sufficient sedative to control restlessness and prepare for subsequent suturing, spinal puncture or examinations. No magnesium sulphate should be given at this time.

III. Period Following Shock.—Temperature, pulse, respiratory and blood-pressure records continued; readings every half-hour.

Lumbar puncture with pressure reading, and drainage if fluid is bloody or pressure above ten millimetres mercury.

Suture of wound with débridement and necessary reconstruction in a properly equipped operating room, if possible.

X-ray of head and other parts only if absolutely necessary to locate foreign bodies, bone fragments or a marked depression. X-ray evidence of a

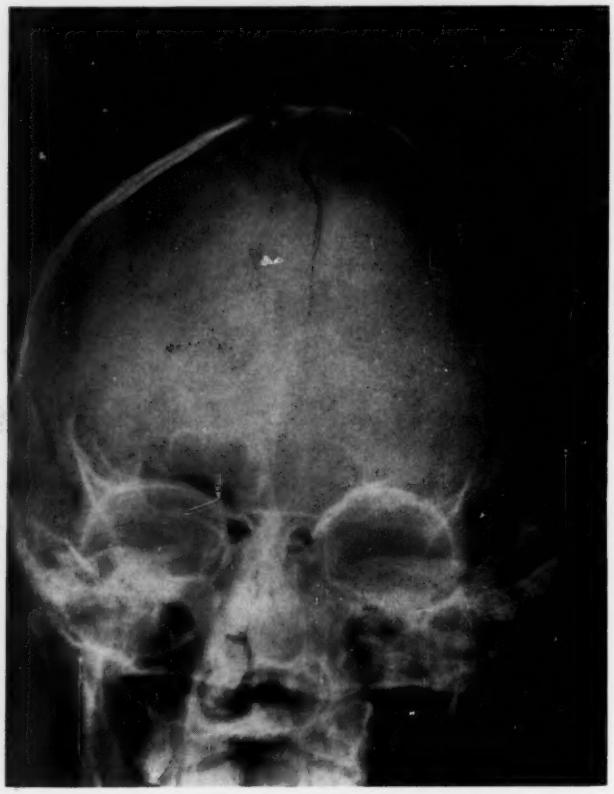


Fig. 18.—Linear fracture of the vault. Compression or thrombosis of the superior sinus may produce venous stasis and profound cerebral œdema in spite of all measures of dehydration and spinal drainage employed. Two verified cases in the author's series were characterized by prolonged and continuous stupor (ten and eighteen days, respectively) up until the time of death. The patients suggested a state of profound narcosis, requiring tube feeding until the end. Slow and delayed ingravescent venous hæmorrhage into the subdural space may occur with fractures which cross the large dural venous sinuses.

skull fracture will offer no aid to treatment unless compounded or greatly depressed. Satisfactory films are not obtained until the patient is coöperative. X-rays taken on the second, third or fifth day after the injury serve to confirm the physician's diagnosis; are excellent medicolegal records and spare the patient from additional shock, as well as the roentgenologist from a difficult duty usually requiring repetition. Patients do not die from "fracture of the

skull." They do, however, die from shock, œdema and intracranial hæmorrhage. The point and extent of fracture (unless compounded or depressed),

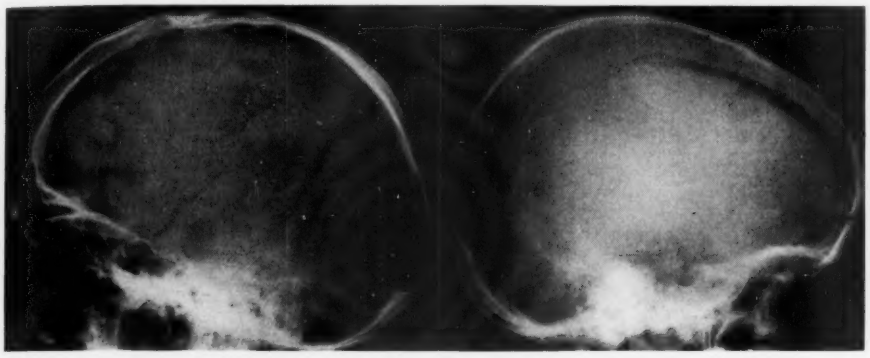


FIG. 19.—Fracture in the temporal region crossing the middle meningeal artery. Subdural hæmorrhage frequently a complication of this area. Stereoscopical X-ray films are required in order to be sure that normal vessel markings in the skull are not mistaken for lines of fracture.

FIG. 20.—Extensive linear fracture of the skull without complications.

do not usually indicate the site of greatest brain damage. Too frequently laceration and hæmorrhage are extensive and contrecoup (Figs. 16 and 17). Frequent neurological examination and careful observation of progressive signs will determine the location and the necessity for surgical intervention rather than the X-ray evidence obtained.

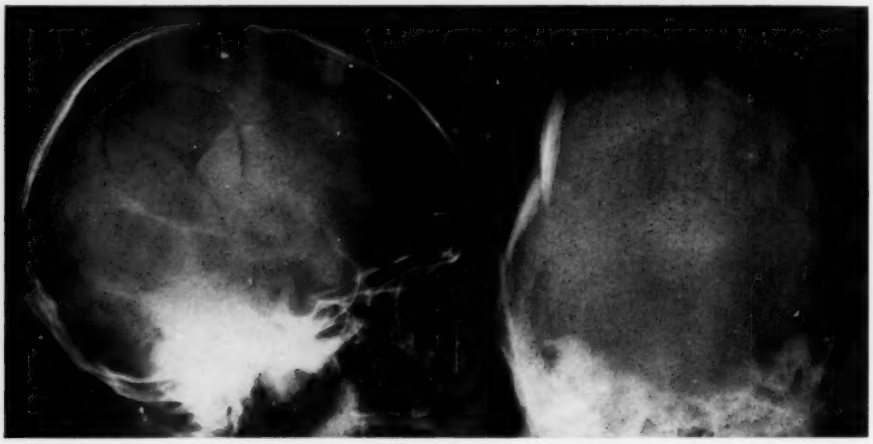
FIG. 21.—Focal depressed fracture of the skull, with satisfactory response to measures of dehydration. Elevation of the fragments on the tenth day following injury, after signs of cerebral œdema and pressure had subsided.

Good X-ray films may be of extreme importance especially if a shift of the pineal gland is shown. The patient must be quiet and coöperative to obtain proper films. Too frequently much valuable time is lost by sending the patient directly to the X-ray laboratory when delay in necessary treatment may mean a life (Figs. 18, 19, 20, 21, 22, and 23).

Detailed neurological examination with especial reference to the pupils (dilated pupil suggests the side of the brain with greatest involvement). *Magnesium sulphate* by mouth or bowel, depending upon general hydration state of the patient and need for dehydration. *Repetition of glucose* intravenously, depending upon requirements of blood volume, pulse and blood-pressure. *Sufficient sedatives* to insure quiet and rest. *Ice-bag to the*

head. Hexylresorcinol, grs. x. q. 4th hour, if cerebrospinal leak occurs from nose or ear. Dichloramin T. dressing to ear (t.i.d.) if draining cerebrospinal fluid. Argyrol, 10 per cent. in each eye (t.i.d.) if spinal fluid is draining from the nose. Sponge q. half-hour for temperatures over 103°. Patient placed on twenty ounces of liquid and "dry" or solid diet if spinal fluid clear; thirty ounces of liquid are allowed if spinal fluid is bloody, and during period of daily spinal drainage.

PERIOD OF RECOVERY.—Temperature, pulse, respiratory and blood-pressure readings may be recorded fourth hour after the critical stage is passed. Strict control of liquid intake should be maintained until the eighth to the tenth day (longer if patient is not progressing satisfactorily). Cerebrospinal fluid leak, over-dehydration or emaciation may require forcing of fluid. If given by vein, skin, or mouth, the amounts should be known and excess avoided.



FIGS. 22 and 23.—Anterior and lateral views of skull showing extensive depressed fracture of the skull in the right parietotemporal region. Profound stupor, subarachnoid hæmorrhage and high spinal pressure. No focal neurological signs. Patient's condition successfully managed with repeated spinal drainage and dehydration by Dr. H. M. Genkins. Conscious on the second day; symptom-free at the third week. Referred to the author for elevation of bone fragments (cosmetic reason only), at the fourth week following the injury.

Enemas or colonic irrigations permit water absorption from the bowel. An ounce of magnesium sulphate to a pint of water will prevent absorption and not produce dehydration, when enema alone is desired. One ounce of glycerine added to the mixture assists in obtaining a prompt return. Daily spinal drainage to be continued until fluid is xanthochromic. The patient may be permitted out of bed from the fifth to ninth day, depending upon the severity of the symptoms. Discharge from the hospital usually occurs on the tenth to twelfth day in patients treated along appropriate lines of dehydration.

It is important that the patient learn to measure his liquid intake and keep a daily record of this as well as his output. Daily weight is a guide to water-storage of the body (one pint weighs approximately one pound). With this

knowledge the patient may prevent rapid storage of fluid and the subsequent symptoms of headache, dullness, loss of attention and memory defects.

A cheap measuring glass is furnished the patient; a diet regulation (Table V) determined upon, and blank forms for the continuation of his records at home. These must be maintained and submitted for check-up on his return to the follow-up clinic, one and three weeks after discharge.

TABLE V

Diet Form and Instructions Used in Maintaining Dehydration

Total allotment of fluid per twenty-four hours (tea, coffee, milk, water, soup, fruit juices, *etc.*).....

Total allotment of sugar per twenty-four hours.....

Diet should consist of red and white meats, eggs, fresh water fish, dry cereals and the vegetables listed below in any variety, as well as butter, cheese, nuts, *etc.*

Portions of food should be moderate.

Meals of equal importance.

Avoid overeating at any time.

Avoid eating between meals.

One uncooked vegetable (carrot, lettuce, celery) *and* one fresh fruit (apple, orange, ½ grapefruit, pear, few grapes, *etc.*) allowed daily. Where juicy fruits or vegetables high in water content are desired, exchange for appropriate amount of fluid can be made by *cutting* total liquid intake allotted for the necessary amount substituted by the fruit or vegetable.

VEGETABLES RECOMMENDED

Potato (baked, fried, French)
Peas
Beans, navy and lima
Carrots, Beets, Parsnips } Drained of juice and served dry as possible.
Rice (dry steamed)
Corn

VEGETABLES TO BE AVOIDED OR EXCHANGED FOR LIQUID

Asparagus	Cauliflower
Tomatoes	Onions
String beans	Spinach
Squash	All greens
Turnips	Sweet potatoes
Cabbage	

FOR THIRST

Warm listerine gargle. For water may be substituted orange juice, grapefruit juice, White Rock, buttermilk, milk, tea, coffee, clear unseasoned soup.

AVOID SOGGY DISHES

Stews, puddings, macaroni, gravy, apple sauce.
No creamed preparations.

ALLOTMENT OF LIQUIDS

Breakfast.....ozs.
Breakfast to lunch.....ozs.
Lunch.....ozs.
Between lunch and dinner.....ozs.
Dinner.....ozs.
After dinner.....ozs.

AVOID FRUITS SUCH AS

Melons, Peaches, Plums, Strawberries, Cherries } These may be exchanged for a proportionate amount of allotted liquids.

TABLE V (*Continued*)

SUGGESTED DIET PROPORTIONS	RESTRICTIONS
Breakfast: dry cereal (shredded wheat, corn flakes, puffed rice or wheat, *etc.*) with *measured* amount of milk or cream. Buttered toast, egg, measured amount of coffee.	*No Salt Added to Food* No salty foods such as fish, chipped beef, saltines, pretzels, olives, salted nuts, *etc.*
Lunch: 1 potato, 1 other vegetable such as listed above. Red meat, fowl, cheese or fish (unsalted). Bread and butter, custard or junket.	*No Sweets* No ice cream, syrup, honey, jelly, cake, candy, canned fruits with syrup sauce. No sweet puddings, desserts or pie.
Dinner: 2 vegetables from above, meat or eggs. Measured allotment of tea or coffee, milk or unseasoned soup. Fresh apple, salad or celery. No desserts. Fluids as above.	DESSERTS (CHOICE OF 1) Unfrosted cake, moderate portion 1 cup custard 1 junket Cookies (without icing or sugar) Jello No sweet puddings, icings, pie, *etc.*
Enemas only as prescribed.	WEIGHT DAILY "A pint is a pound." Gain or loss in fluid can be checked by this means.

The diet and fluid restrictions are required for three to six months following severe head trauma.

RESULTS OF TREATMENT

It has been found in our series that patients maintained on a solid, dry diet and twenty total ounces of fluid per day, promptly regain consciousness, are free from headache, and little or no spinal fluid can be obtained by lumbar puncture after the second day. This places the cerebral mechanism in a physiological state of rest, free from hydraulic compression, and permits the optimal cerebral circulation during the period of recovery; it shortens the interval of unconsciousness, and preserves the higher centres of intelligence.

After discharge from the hospital (patients with severe cerebral trauma, with or without bloody spinal fluid), the patient is placed upon a total of thirty-two ounces of liquid per day for the ensuing three months. The diet should contain solid foods, and strict avoidance of vegetables, high in water content, or the consuming of excessive volumes of food, should be emphasized.

In this series of observations, the patients have shown rapid improvement following cerebral injury, and have been free from headache, loss of initiative, memory disturbance, and mental fatigue, so common in the former group. They have returned to full activity in many cases within three months of the injury, where formerly a nine months' period of disability was to be expected. The patients have maintained a low fluid level of their own accord. "When they took more liquids they did not feel as well," they had headache, dullness, and voluntarily returned to their former restrictions of fluid and diet.

Encephalography (Fig. 24, A and B) has clearly shown that widespread cortical atrophy of the brain occurs within three weeks following cerebral trauma. Many post-traumatic cases have shown not only focal scars over the cortex of the brain, but an atrophy out of proportion to the site of injury or its extent, and this atrophy of the cerebrum and cerebellum is bilateral and general-

FIGS. 24A and B.—Encephalogram of patient at the fifth week after injury. Patient absolutely symptom-free at this time. Note generalized brain atrophy (vertex, midline, subarachnoid spaces) at a distance from the fracture, secondary to subarachnoid bleeding and pressure from spinal-fluid accumulations. Spinal pressure on admission 30 mm. Hg. Fluid very bloody, full drainage. Puncture four hours later, pressure 32 mm. Hg. full drainage; puncture eight hours subsequently, pressure 18, full drainage. Pressure after second day 10 mm. Hg. on dehydration.

Bone fragments elevated at sixth week after injury, dura found lacerated, small area of local brain destruction (fifty-cent piece). Recovery with return to work in three months. Symptom-free now, one and a half years. Continuing work as gas-station attendant.

The case illustrates depressed fractures are not immediate surgical problems if general pressure problems are capable of conservative treatment. The cerebral atrophy shown occurred within five weeks and is typical of the changes seen by encephalography in the post-traumatic, with or without depressed fractures. Intense pressure during the first few hours following injury is probably entirely responsible for these changes as local damage was comparatively slight. The end-result indicates the importance of control of spinal-fluid pressure and volume from the beginning of treatment. The brain damage is reduced to a minimum; the patient's life assured, and his economic readjustment made possible.

The author considers this case highly important, not only from the standpoint of survival and full recovery in a patient whose condition seemed hopeless from the start, but this is one of the earliest encephalograms recorded, made on a demonstrably focal injury, where all clinical and neurological findings were under constant observation prior to the encephalogram, and for the ensuing eighteen months. The mechanism of post-traumatic cerebral atrophy has become more firmly established by a group of such observations.

ized. Pathologically such brains reveal anæmic changes and degeneration similar to that described by Hassin, and termed *pressure atrophy*. An atrophy of the soft, delicate gray matter of the brain is not surprising in view of familiar observations regarding "pressure atrophy" elsewhere in the body. When a ring is worn upon the finger, when glasses rest upon the nose, or exert pressure upon the cartilage of the ears, when casts or constricting bandages are applied to the surface of the body, characteristic pressure atrophy occurs. The results of pressure from a cast applied to the extremity and the rapid consequent atrophy are readily recognized and accepted by the profession. The fact that the brain is acted upon by an "hydraulic cast" encased by an unyielding skull seems to have escaped the recognition which it should have had from the profession.

The obstetrician depends upon hydraulic pressure for dilatation of the cervix in normal labor. The hydraulic atrophy produced in distention of the bladder and renal pelvis is well recognized. The control, therefore, of a similar cerebral hydraulic mechanism is necessary to prevent widespread atrophy of the cortical surfaces surrounded by fluid (Fig. 25).

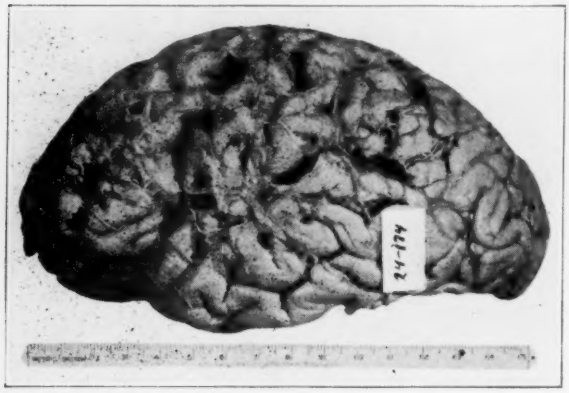


FIG. 25.—Brain of a chronic epileptic in which the arachnoid has been carefully opened to show the dilated fluid pathways and shrunken convolutions. Note how the under surface of the frontal lobe, the occipital lobe and the temporal lobe has escaped this process. The atrophy is confined to the cerebrospinal fluid circulating field and to the pathways themselves. We believe this to be due to the hydraulic "cast" of pressure exerted in this area, producing gradual pressure atrophy of the adjacent cortex. (N. W. Winkelman.) (Courtesy A. M. A.)

It is evident that the members of our profession interested in industrial medicine and the economic readjustment of patients suffering from head injuries, must secure the early protection and subsequent preservation of the cortical areas so necessary for intellectual activity. The cerebral hydraulic pressure mechanism should be treated in the same manner in which one would deal with an obstruction to the neck of the bladder or renal pelvis, that is, continued and prolonged fluid drainage must be the first consideration, and the accurate control of fluid production should be maintained during the period of inadequate elimination. Thus, in attacking the problem from both angles, we shall not continue the paradoxical treatment so long in vogue of draining the spinal canal or decompressing the brain, only to follow this beneficial procedure by immediately introducing large quantities of fluid into the individual by mouth, bowel, or vein, destroying the advantages gained through cerebral decompression.

To eliminate surgical decompressions in the treatment of head trauma is to step further forward toward assisting in the industrial and economic readjust-

ment of the patient, because brain destruction and atrophy invariably occur at the site of surgical decompression, whether inflicted at the time of surgical intervention, or subsequent to the pressure exerted at this point of opening by the resultant cerebral hernia. This leaves the patient with an organic loss of brain in the region of the decompression, superadded to the loss directly due to the injury itself. Not only is this a most important medicolegal "compensation" factor, but a definite inferiority complex develops, characterized by fear and anxiety because of the opening in the skull and the danger of direct injury, in time producing a typical post-traumatic psychosis. Finally, such disfiguring decompressive openings limit the patient in his possibilities of securing work or engaging in activities that offer the slightest danger of trauma to the site of the cranial defect.

In summarizing the important industrial and economic aspects of head injuries, I wish to emphasize that early and continued dehydration as a form of decompression should be immediately instituted and continued to the point of recovery of conscious function. The hydraulic compression from chronic, increased intracranial pressure should be controlled for a period of months following cerebral injury, to prevent the increase of brain atrophy so characteristic in this group. The symptoms of post-traumatic headache, vertigo, mental torpor, mental deficiency, loss of initiative and concentration may frequently be prevented if careful supervision and control of fluid intake have been maintained following severe cerebral injury.

ECONOMIC READJUSTMENT FOLLOWING HEAD INJURIES

In dealing with the economic and industrial aspects of head injuries, it is necessary to dispel at once the conception of certain mysterious and ill-defined consequences resulting from injuries to the brain during the acute period of clinical study, and to recognize the occurrence of certain definite common sequelæ which may be attributed to organic changes not detectable by ordinary neurological examinations.

During the past few years, it has become clear that the early administration of prompt and efficient treatment in cases of severe injury to the brain not only assures the patient of a better chance of survival, but determines to a large degree the resultant mental disability. Too frequently the clinician's attention is directed only toward the preservation of life by palliative means, with the result that the patient is passed along to the neurologist or neurological surgeon as a chronic case of mental deterioration and an almost certain total economic loss.

The close correlation between the acute stage of the problem and the subsequent post-traumatic mental sequelæ has been a matter of careful investigation during the past nine years. We have recognized that not only must the patient be protected from his immediate danger of death, due to involvement of the "vital" centres by pressure, but also that the entire function of the brain, dealing with intelligence, memory, and judgment, requires active consideration during the early hours following a severe cerebral injury.

For our purposes, the brain may be divided into two areas dealing pri-

marily with separate functions: first, those nuciei concerned with maintaining life, such as the vasomotor, cardiac, and respiratory centres which we term "vital" centres; and, second, those portions of gray matter which have to do with intelligence, appreciation, and expression of the individual in relationship to his environment, situated in the cortex of the cerebrum and cerebellum, which we may term the "gnostic" regions. From the immediate clinical standpoint, the *vital* centres are most important, but from the economic and industrial standpoint the *gnostic* areas of the brain are necessary to permit the reestablishment of the individual to his social state.

The vital centres are situated at the base of the brain (Fig. 26) in the region of the third ventricle, the pons and medulla, and definitely indicate the zone of danger toward which the clinician should direct every measure of protection. The cerebral hemispheres and cerebellum are masses of functioning and reacting tissues, which are unnecessary for the actual continuation of life, but are of the highest importance in the intelligent reactions and conscious expression of the individual. Injury or destruction of the former (vital areas) is

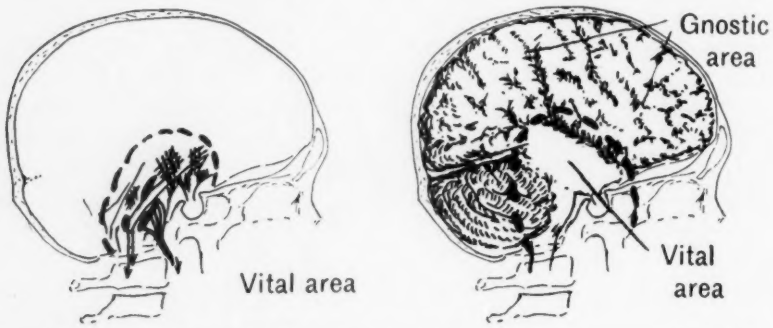


FIG. 26.—Division of the brain into (a) vital and (b) gnostic areas. The vital areas are concerned during the immediate post-traumatic phase. The gnostic areas are not essential to life, but of great importance to economic readjustment. Injuries to the former are fatal; to the latter, they leave evidence of mental and physical disability. (Courtesy S. G. & O., vol. 54, p. 362, 1932.)

followed by death within three to six hours, and all of the present clinical methods at our disposal fail to help the patient. Destruction or injury to the latter (gnostic areas), however, is characterized by a loss of mental function and transient or continued paralysis. The clinician must keep clearly in mind that the neurological examination reveals the signs of loss of function of the higher centres, whether it be inhibitory in nature, controlling reflex, or psychic manifestations, or an apparent paralysis or anæsthesia. The loss of consciousness becomes as important as an actual paralysis in the early phases of the problem. Furthermore, there is a great danger that the factors leading to local cortical compression, which are responsible for the loss of the conscious elements, may spread in the form of œdema to the vital basal centres, and the patient perish from this complication.

Unlike any other organ, the brain is contained within a space of fixed volume (the skull, after closure of the sutures), and the function of this organ must be maintained within these volume relationships. In the presence of adequate oxygen and circulation, brain tissue will survive and tend to function,

but with the advent of œdema or gross hæmatomata, the blood supply becomes insufficient to supply adequate oxygen, and in this circumstance the "gnostic" areas suffer primarily and most severely, not only because they are at the moment least important, but because they receive five times the blood supply of the basal cells and are exposed to surface compression, and are consequently more sensitive to proportionate diminution in circulating blood volume (oxygen).

As the skull determines the limitation of intracranial volume, and as there can be no increase in volume by any of the components contained therein without an equal withdrawal of one of the factors, the problem of treatment of intracranial injuries resolves itself into attempts to maintain optimal circulation by subtracting from the cranial contents a certain volume of the least important components.

The vital centres at the base of the brain are well protected by solid masses of white matter and receive their blood supply directly from the basilar artery and the circle of Willis, and their capillary network is not exposed to the surface compression which occurs over the cortex during periods of generalized pressure. However, as the process of œdema begins in the cortical layers of the brain, a swelling in the brain volume occurs, with rapid continuation of the œdema into the basilar areas. Thus, the terminal picture is usually one of vasomotor failure associated with respiratory irregularity, and as oxygen becomes less available to the brain, due to a failing circulatory pressure and paralysis of the vasomotor mechanism, the respiratory centre fails, and leaves the intrinsic mechanism of the heart to beat on for a few moments after all other neurological activity has ceased.

If we are to accomplish not only a protection of the vital centres but an early reëstablishment of cortical circulation to protect the gnostic areas, the treatment must be vigorously directed toward complete control of the cerebral volume relationships, and the patient must not be permitted to remain in an unconscious state if it is possible to prevent it. This means that the clinician must continue the method of treatment, not only to the satisfaction of the vital centres, but must aim toward sufficient return of circulation to permit cortical function as soon as possible following the injury.

The follow-up results on the post-traumatic group maintained on fluid balance after discharge from the hospital has shown 92 per cent. free from the post-traumatic symptom-complexes usually designated as "neuroses," "compensationitis," "mentally retarded" or "deteriorated" types. The "dehydration" case histories indicate the astonishing readjustments that have been possible in the severely injured group of "brain workers" as well as the laboring class.

The improvement noted in the chronic types of post-traumatic neurosis and deteriorated groups that have been afforded the application of the principle of dehydration even after years of neglect, clearly indicates this group may be improved approximately 30 per cent. (See Whitney and Hunsicker[29] and Fay.[15, 30])

SUMMARY

The principles of dehydration have been presented as they apply to patients suffering from acute cerebral trauma. It seems justifiable to attribute the definite reduction in mortality (11.4 per cent. in this group) to measures which establish and maintain a better blood supply to the brain organ as a whole, when hæmorrhage, œdema and pressure threaten its survival.

The gratifying results obtained in the post-traumatic group indicate that continuation of the principle itself offers the opportunity of protection to the brain against chronic increased intracranial pressure, with the correction of the so-called post-traumatic syndromes and "neuroses."

The ability of these patients to again engage in their former activities in from three to six months following severe head trauma presents a solution for a staggering economic problem.

In the last analysis, the clinician strives by every means at his disposal to reëstablish the necessary blood supply (oxygen and nutrition) required to promote healing of injured tissue and permit retention of all function in the organ affected. As the unyielding craniovertebral boundaries introduce additional problems of physics and hydraulics into the limited environment of the cerebral organ, these obstacles must be removed by clinical and mechanical measures.

The term, "dehydration," has come to be applied to the methods directed toward a reëstablishment of *normal functional relationship* between the volume components of the craniovertebral cavity, and in this respect the "dehydration treatment" is obviously indicated only where states of abnormal *hydration* exist. The wise regulation and readjustment of fluids when pathological states exist must be determined for each individual case as one would the dose of a drug, and it has often been said that "the dose of a drug is *just enough*."

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MOTOR AND SENSORY OVERLAP IN THE SPINAL ROOTS

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It has been known for a long time that section of a single spinal root is followed by neither paralysis nor sensory loss of any importance, but that section of two adjacent roots is followed by such loss. To explain this overlap, Sherrington[1] in 1898 states that one segment of the cord supplies parts of adjacent segments of the body with both efferent and afferent fibres, and that "it is the position of the ganglion, and not that of the so-called spinal 'origin,' that is the key to the segmental position. In other words, *the situation of the nerve-cells, not that of the nerve-fibres, marks the segmental position of the sensory nerve.* Growing out from the ganglion cells, its fibres wander distally into skin and muscles, and these trespass considerably beyond the limits of their proper metamere for they considerably overlap. Centripetally they extend even more boldly into regions outside their original metamere, in fact, into segments quite remote. A similar arrangement exists in the motor nerves, but I and A. S. F. Grünbaum have pointed out that the region of spinal origin of the fibres of a motor root, unlike that of the sensory root, is of strictly local extent in the spinal cord, confined to one, its own, segment. That is to say, the seat of the motor cells of the segmental nerve is, like that of the sensory cells of the segmental nerve, not plurisegmental, but confined to one, the original segment. The nerve-cells of a metamere do not wander beyond the confines of the metamere in which they arise, but the nerve-fibres rising from them are eventually in great part thrust quite beyond the confines of the original metamere. This trans-segmental trespass of the nerve-fibres is comparatively slight in the skeletal musculature of the trunk, distinctly greater in that of the limbs, especially at the free apex of each limb, greater still in the sensory structures of the skin and yet greater in the distribution of efferent fibres to the vertebral ganglia of the sympathetic, but greatest in the sensory fibres distributed from the root ganglion to the segments of the spinal cord."

Just why this should occur has puzzled investigators who wished to go beyond a teleological explanation. I cannot agree with Sherrington, however, if I interpret his statements correctly. The position of the ganglion, according to the following hypothesis, would seem to be of little importance as compared with the position of the intramedullary cells of origin of the secondary pathways.

We have been accustomed to consider as the segment of the cord that particular area which gives rise to the corresponding roots dorsal and ventral, the boundary between adjacent segments lying between the lowest fasciculus of the upper root and the uppermost fasciculus of the lower root. Looking

at it from the developmental point of view, however, it will readily be seen that segmentation in the body does not occur in this fashion. Dermatomeres, myomeres and myelomeres in the primitive condition lie opposite one another, composing a single segment, and the various structures, vessels, nerves, *etc.*, run between the segments. It is therefore likely that a single myelomere will supply its corresponding myomere and dermatomere, but through two different roots. The point or division between adjacent segments of the cord should be made, therefore, at the level between the upper and lower portions of each root (Fig. 1).

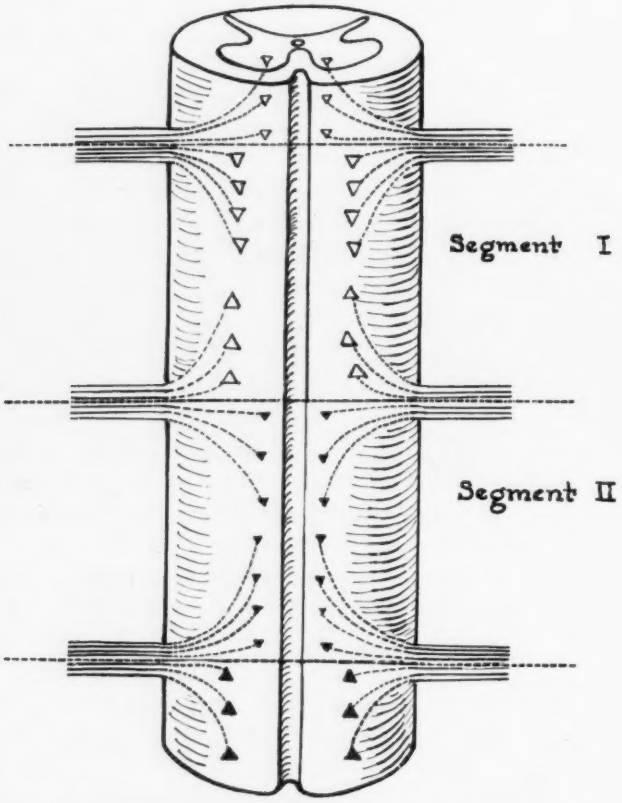


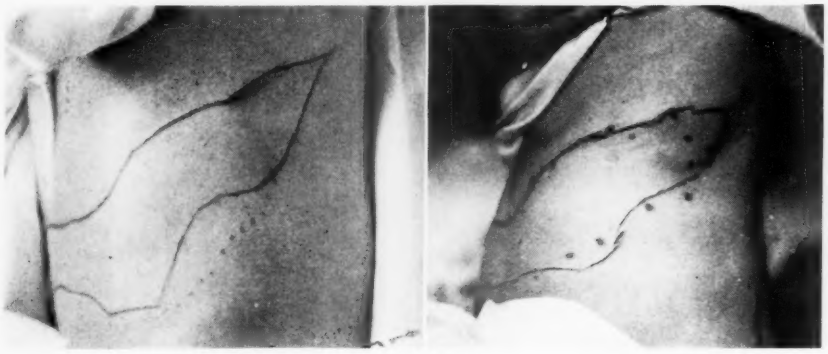
FIG. 1.—Schematic representation of the ventral roots showing their relationship to segmentation in the spinal cord. The longitudinal cell columns are indicated as being restricted to a single segment, their efferent fibres leaving by way of two adjacent roots.

The reason that no paralysis or anæsthesia results from section of a single root is that only a portion of the fibres from any one segment of the spinal cord has been interrupted.

Most of the muscles are unisegmental and are innervated through two roots, so that section of two adjacent ventral roots will result in complete paralysis of such muscles. It is known, however, that section of two adjacent dorsal roots seldom results in an even band of cutaneous anæsthesia encircling

half the trunk. Indeed, widespread dorsal rhizotomy, according to the report of Sicard, Haguenau and Mayer[2] may be followed by extreme variations in the resulting bands of anæsthesia. An example of the cutaneous anæsthesia following section of the tenth and eleventh thoracic dorsal roots is shown in Fig. 2. The band of anæsthesia is irregular and does not reach the mid-line posteriorly. To explain such variations we must suppose either that fibres cross the mid-line from the opposite dorsal roots, or that there is still further overlap from neighboring roots on the affected side. The first possibility is unlikely, even disproven by the mid-line section for laminectomy. In regard to the second it is possible that by means of anastomotic filaments connecting adjacent thoracic nerves as well as through the formation of the cervical and lumbar plexuses, fibres from one spinal ganglion may find their way to the periphery by two or more different nerve-trunks.

These anastomoses are necessary to explain the wide overlap. The mere



(a) 1928 (b) 1934

FIG. 2.—Area of cutaneous anæsthesia —— and analgesia . . . . . following section of the tenth and eleventh thoracic roots for the removal of a tumor. The band of disturbed sensibility is not uniform and does not reach the mid-line posteriorly. Definite reduction in size of the area has occurred during a period of six years.

overlapping in the distribution of the fibres contained in one spinal root but passing from two adjacent segments of the cord into the two corresponding adjacent cutaneous fields will not explain the irregularity of the anæsthesia, since section of two adjacent roots would divide all the fibres going to the intervening dermatomere and would produce a complete band of anæsthesia (Fig. 3). Moreover, this would leave no possibility of reduction in the area of anæsthesia such as may occur with the passage of time.

Contrasted with the irregularity in the band of anæsthesia following dorsal rhizotomy is the straight smooth boundary of anæsthesia due to complete transection of the spinal cord itself. Segmentation in the spinal cord thus appears to be much more even and stable than that revealed in the dorsal roots. The apparent wide overlap in the cutaneous distribution of the root fibres may be compensated for by redistribution of such fibres in the tract of Lissauer. In this tract the entering root fibres run a variable distance, even as much as two or three segments, before forming synapses with the

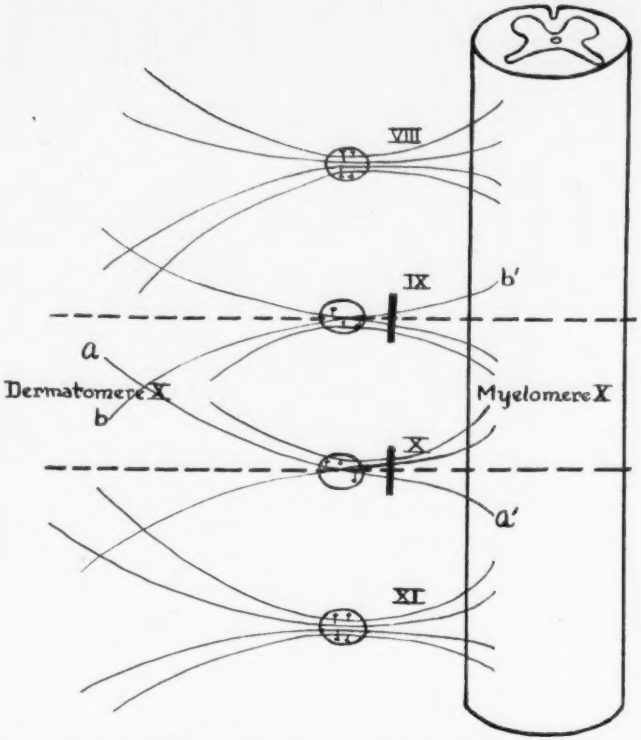


FIG. 3.—Diagram illustrating a hypothetical type of overlap in the dorsal spinal roots. Fibres from one dermatomere run through the ganglion to a different segment (a-a'; b-b'). Such overlapping is impossible, since section of roots IX and X would interrupt all impulses from dermatomere X and would result in complete anæsthesia of the whole segment.

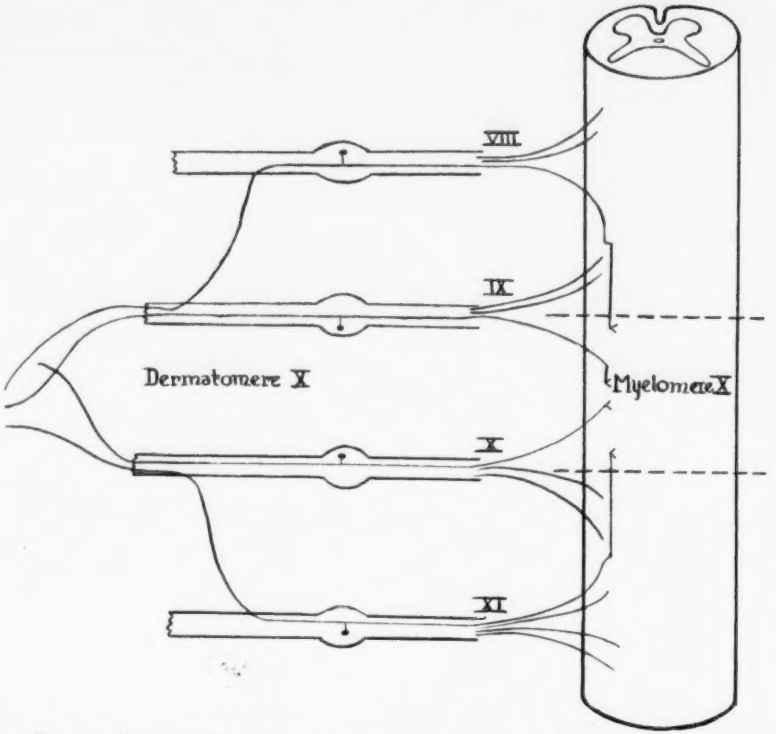


FIG. 4.—Diagram explaining wide cutaneous overlap. Cells derived from the ganglionic crest may be situated in a distant ganglion, but by means of anastomotic filaments distal to the ganglion, send their peripheral processes to the proper dermatomere, while the central processes reach the proper myelomere by way of the tract of Lissauer.

cells of origin of the secondary pathway. The unduly wide overlap in the roots, then, may be explained if we assume that nerve-fibres whose central prolongations are destined to form synapses at a certain level run to the periphery by way of a distant ganglion. For instance, certain cells in the ganglionic crest may become dislocated so that they lie in the eighth thoracic ganglion yet send their peripheral fibres by means of anastomotic filaments to the tenth thoracic dermatomere, and their central extensions by way of the tract of Lissauer to the tenth thoracic myelomere (Fig. 4). Sectioning the ninth and tenth and even the eleventh dorsal roots, then, might not interrupt all the nervous impulses coming from the tenth thoracic dermatomere.

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INTRACRANIAL OPERATIONS IN THE SITTING POSITION

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During the last four years, a majority of the major intracranial operations at the Cleveland Clinic have been performed with the patient in the sitting position. This position has been found to possess many very definite advantages and also certain disadvantages. The idea of placing the patient in the erect posture for craniotomy is not new, and no claim is made for originality in any of the observations to be described. Frazier[1] early appreciated the advantages of the erect posture in operations on the sensory root of the fifth nerve. In several of his communications on trigeminal neuralgia he has stated that in this position there is less bleeding, the patient requires less ether, and the field of operation is on a level with the eyes of the operator, which facilitates exposure. For many years de Martel[2] has advocated having the patient in the sitting position during intracranial operations. He has employed this method since 1911, and has found that elevation of the patient's head decreases hæmorrhage and aids respiration. On account of the greater likelihood of syncope in this position, he favors local anæsthesia, which allows earlier recognition of the syncope which can be combated by lowering the patient's head.

In 1930, I began to place the patient in the sitting position for operations on tumors of the cerebellum, with the hope of overcoming certain difficulties, such as the respiratory embarrassment, and also the occasional tendency for the cerebellum to bulge through the craniotomy opening. The cerebellar head rest was attached to the arms of a dental chair, and several operations upon the cerebellum were carried out in this position. After a trial extending over several months, the advantages were so obvious that alterations were made in the head rest so that supratentorial tumors could be attacked with the patient in the same posture. In the last three years, I have reverted to the use of the prone position in only one case of suboccipital craniectomy. This patient was a woman, aged seventy-six years, whose ninth nerve was sectioned for glossopharyngeal neuralgia.

From our experience with this position, its advantages over the horizontal position may be enumerated as follows: (1) There is a reduction of intracranial venous pressure resulting in diminished bleeding, lowering of intracranial pressure and a lessened tendency to cerebral œdema consequent to operative manipulations; (2) freedom from respiratory embarrassment; and (3) easier access to the patient for the anæsthetist, as well as the operator. The disadvantages of this position are: (1) occasionally a patient goes rapidly

into profound shock; and (2) the lowered intracranial venous pressure may favor air embolism, if a dural sinus is opened.

The reduction of the intracranial venous pressure, of course, is the result of the improvement in venous return which occurs on elevation of the head. It is due partly to the pull of the column of blood from the brain to the right side of the heart and partly to a lowered intrathoracic pressure. To anyone who has observed operations with the patient in the erect, as compared with

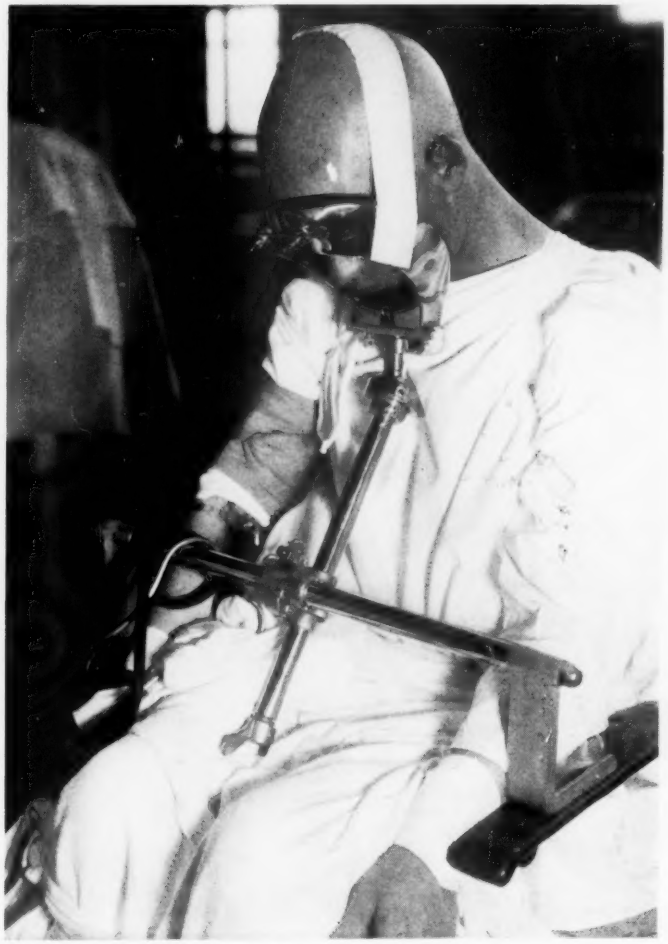

FIG. 1.—Patient in position for a suboccipital craniectomy or cervical laminectomy. The head rest is lined with sponge rubber and is adjusted to the contour of the patient's face.

the horizontal position, the diminution of venous bleeding and the ease of its control in the former cannot help but be apparent. The reduction of the intracranial pressure is the most striking and significant advantage gained by elevation of the patient's head. This, of course, is secondary to the reduction of the intracranial venous pressure. This reduction in pressure can be measured by performing a cisternal or ventricular puncture and recording the

pressure in the same patient in both the horizontal and sitting positions. If the intracranial pressure is below 150 millimetres of water in the horizontal position, it will be subatmospheric in the erect posture. If the intracranial pressure is greatly increased in the horizontal position, it will be found to be at least 200 millimetres lower than when the patient is sitting erect.

When the patient is sitting upright, except in the case of severe intracranial pressure, there is no significant herniation of the brain when the dura

FIG. 2.—The exposure for resection of the fifth and ninth cranial nerves and second and third cervical posterior roots on the right side for relief of pain from carcinoma. Illustration shows the ease of exposure of the eighth nerve and angle. Combined hemisuboccipital craniectomy and hemilaminectomy.

is opened. With this reduction of herniation, intracranial exploration can be more thorough and extirpation of the tumor is rendered more simple. Because the tumor can be removed with less trauma and less retraction, immediate cerebral œdema is reduced to a minimum. In no case of cerebral tumor in which the operation was performed with the patient in the erect posture, has it been necessary to sacrifice the bone flap on account of herniation of the brain.

As de Martel has stated, "the sitting position favors easy respiration and

is the position all patients instinctively assume when respiration is labored." Certain patients who tend to breathe stertorously when lying horizontally, breathe quietly and without effort in the sitting posture, and also the head can be flexed more without a tendency to stertorous breathing. This is a point of considerable importance in the attack on a cerebellar tumor.

When a brain tumor is removed, a procedure which is likely to be slow and tedious, it is decidedly advantageous that the various members of the operating team are comfortable and have easy access to the patient. This is especially true of the anæsthetist. With the patient in the sitting position, the anæsthetist is not required to sit under a tent of draperies, and therefore has a better opportunity to observe the patient's condition and to minister to his needs. In addition, the patient's arms are available for intravenous medication or for transfusion, should this prove necessary.

In a series of fifty-six suboccipital craniectomy operations, no distinct disadvantages of the sitting position have appeared. These patients have shown no fall in blood-pressure which could not be combated by hypodermic stimulation or intravenous fluids. In operations on the cerebral hemispheres, however, the story is different. The sitting position, of course, would not be desirable or feasible in operations on tumors arising from the floor of the anterior or middle cranial fossæ or from the sellar region. With the operative field in these situations, it would be necessary to lift the brain away from the lesions and against the force of gravity. The sitting position, therefore, is not employed when a tumor is suspected on the inferior surface of the cerebral hemisphere. In the past four years, seventy-eight craniotomies other than suboccipital, have been performed with the patient in the sitting position, as compared with 147 similar operations using the supine position. In this series of seventy-eight cases, a rapid and profound shock appeared in two instances and was accompanied by visible air emboli in the cerebral vessels. Both of these patients were past sixty years of age, had cerebral arteriosclerosis and arterial hypotension, and the lesion in each case was a parasagittal meningioma. In one of these, the sudden syncope undoubtedly contributed to a fatal termination. This patient also had severe asthma and emphysema. Since these experiences, I have not employed the sitting posture in operations upon elderly or arteriosclerotic subjects, particularly when there is an associated hypotension.

De Martel stresses the advisability of employing local anæsthesia when the patient is in the sitting posture, in order to permit earlier recognition of threatened syncope. When this complication occurs, he immediately lowers the head. The chair which he employs permits rapid lowering of the head during the course of an operation. Thus far, I have not been able to incorporate this desirable feature in our equipment. Given a chair with this feature, I believe that the last valid objection to this position would be eliminated.

I do not agree with de Martel's dictum regarding the necessity for local

anæsthesia, although it is perfectly true that with local anæsthesia syncope is more readily recognized. But there can be no question also that general anæsthesia, probably by elimination of the psychical factor, reduces very materially the incidence of syncope, and I feel that this reduction in frequency by far outweighs the advantage of its earlier recognition under local anæsthesia. The importance of the psychical factor in syncope is well illustrated

FIG. 3.—Position for frontal or lateral craniotomy. After the field is prepared and the line of the incision marked, the head is fastened to the head rest with a strip of adhesive.

by its quite frequent occurrence in encephalography under local, as compared with its rare occurrence under general anæsthesia. Since 1930, I have preferred to use avertin in cranial surgery. In preparation, the patient receives a hypodermic injection of codeine and scopolamine one hour before operation, followed forty minutes later by the instillation into the rectum of 50 to 100 milligrams of avertin per kilo of body weight.

FIG. 4.—Removal of a left parasagittal meningioma. With the patient in the sitting position, the brain retracts by its own weight.

FIG. 5.—Removal of a similar, though smaller, tumor from the right parasagittal region with the patient in the horizontal decubitus. The bulging brain is being retracted from the tumor.

The objection has been raised that the sitting position in craniotomy may favor the occurrence of post-operative hæmorrhage. In the fifty-six cases of suboccipital craniectomy, a post-operative hæmorrhage was not detected clinically or at necropsy in any case. There was likewise no post-operative hæmorrhage in fifty-one operations for resection of the sensory root of the fifth nerve by the temporal approach. Following seventy-eight craniotomies with the patient in the sitting position, a post-operative hæmorrhage occurred in three instances. This incidence of hæmorrhage is considerably higher than in the series of 147 craniotomies carried out with the patients in the horizontal position, in which there was only one post-operative hæmorrhage. On analyzing these cases, however, it was found that post-operative hæmorrhage occurred only in cases of jacksonian epilepsy in which there was no increase in intracranial pressure. In my experience, this type of case is notorious for its high incidence of post-operative hæmorrhage. Hence the more frequent recording of this complication after operations with the patient in the sitting, as compared with the horizontal position in our series, might be explained by the fact that most patients with jacksonian epilepsy are operated upon in the sitting position. I do not believe that the erect posture during operation favors the occurrence of post-operative hæmorrhage.

The sitting posture is employed routinely in encephalography and in ventriculography. It has also been used in twenty-nine cases of laminectomy on the cervical or upper dorsal spine and in nine operations for removal of the cervicodorsal sympathetic ganglia by the Adson approach. This latter operation, in my experience, is definitely simplified by this technic. In the case of laminectomy, the position is of great value, provided a general anæsthetic is used. In cordotomy when performed under local anæsthesia, in this position, the patient frequently experiences a syncopal attack after the dura is opened. This is caused by the ascent of air into the cerebral subarachnoid spaces. Under general anæsthesia, no significant change occurs when the dura is opened.

The value of the sitting position was strikingly demonstrated recently in the case of a patient with a meningioma at the level of the foramen magnum. This patient had a quadriplegia, the diaphragm was paralyzed and the intercostal muscles were very weak. For this reason, the respirations were shallow and rapid and there was mild cyanosis. This patient obviously would not have tolerated the prone position, but she withstood the operation splendidly in the sitting position and had an uncomplicated convalescence.

SUMMARY AND CONCLUSIONS

The sitting position of the patient, combined with avertin anæsthesia, is recommended for operations on the cerebellum. This position results in (1) a diminution in bleeding, (2) a lowering of intracranial pressure, (3) a lessened tendency to immediate cerebral œdema, (4) an improved respiratory exchange, and (5) it also facilitates access to the patient, particularly by

the anæsthetist. This position is not recommended for operations on tumors about the sella turcica or on the inferior surfaces of the cerebral hemispheres. In other cerebral tumors, the position is recommended with reservation because of the tendency for an occasional patient to go into prompt and profound shock. The position has distinct advantages in cervical and upper dorsal laminectomy and in excision of the cervicodorsal sympathetic ganglia by the Adson approach. It does not predispose to post-operative hæmorrhage.

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TUMORS ARISING FROM THE SENSORY ROOT OF THE TRIGEMINAL NERVE IN THE POSTERIOR FOSSA

PERINEURIAL FIBROBLASTOMA

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Rare as tumors of the gasserian ganglion are, their unusualness cannot be compared to the primary tumors arising from the sensory root of the trigeminal nerve in the posterior fossa.

Spiller,[1] in 1908, reported two cases of tumors of the gasserian ganglion, accompanied with the following statement: "It seems remarkable that the cases of tumor of the gasserian ganglion are not more numerous. I can only believe that these tumors are not diagnosticated in many instances when they exist." This statement seems apropos of those tumors arising from the sensory root of the trigeminal nerve in the posterior fossa, and to this could be added the further statement that possibly these case reports do exist in the literature, but under other captions.

Frazier,[2] in 1918, recorded his experience with tumors of the gasserian ganglion and emphasized the fact that most of these cases were inoperable tumors of the middle fossa. He reported three of his own cases together with forty cases collected from the literature. He reviewed the symptomatology of these cases and stressed the fact of their confusion with true *tic douloureaux*. In differentiating these tumors from true *tic douloureaux*, Frazier pointed out the occurrence of the combination of pain and anæsthesia —the pain more frequently involving the entire distribution of the trigeminal nerve, usually of greater intensity and with no pain-free periods. In the early stages, corneal reflexes are absent, the muscles of mastication are affected, and later the third and sixth nerves are implicated. Additional neighboring symptoms develop depending upon the size and extension of the growth, as well as signs of increased intracranial pressure. The majority of the tumors were sarcoma or endothelioma, but also carcinoma, glioma, gumma, fibroma, neurocyst and aneurisms were described.

According to Hellsten,[3] the ganglion possessed a peculiar resistance to the invasion of tumors, and practically all the tumors arose from some neighboring structure and only involved the ganglion coincidentally. While these tumors in the beginning were limited to the ganglion, they often expanded along the floor of the middle fossa, occasionally invading the orbit, the sella turcica, or even the posterior fossa. Frazier advised evulsion of the sensory root for the relief of pain, even if the tumor could not be removed; and if necessary to relieve pressure, he recommended a subtemporal decompression.

Peet,[4] in 1927, was able to collect a total of sixty-three cases and added two cases of extracranial carcinoma which infiltrated the ganglion by direct

extension through the maxillary division. Other pathological types such as chondrosarcoma, osteochondroma, epithelioma, adamantinoma, lymphosarcoma and neuroblastoma were described.

Cooper,[5] in 1933, was able to collect seventy-six reported cases and added three of his own. In his additional cases, the pathological diagnosis consisted of neuromas, sheath neuromas, neurocytoma, neurofibrosarcoma, fibroblastoma and neurofibroma. He also advocated surgical methods for these cases. As had been previously stated by Frazier, Cushing,[6] and Shelden,[7] Cooper reiterated the possibility of these tumors extending into the posterior fossa.

Upon a review of the available literature, only three cases have been found wherein a primary tumor arising from the sensory root of the fifth nerve in the posterior fossa has been described. It is this uncommon tumor which is the basis of the present paper. Those tumors extending from the middle fossa posteriorly and invading the posterior fossa by secondary extension have not been considered.

CASE REPORT.—A male patient, weight 135 pounds, height five feet four inches, aged forty-six years, storekeeper, was admitted to the hospital March 6, 1931, with a complaint of numbness of the left side of his face, ringing in the left ear and staggering gait. Past history and family history essentially negative, excepting that he always had a "chronic catarrh" and a very severe attack of bronchitis three years ago, followed by a tonsillectomy.

Present Illness.—In October, 1930, the patient noticed a slight ringing in his left ear, but without any loss of hearing. Several weeks later the left side of his face became numb. In February, 1931, he noticed some difficulty in speech, developed a staggering gait, falling primarily to the left. In addition, he had attacks of dizziness from time to time, developed hiccoughs and was drowsy at intervals. He developed personality changes, became untidy and irresponsible. Within the last several weeks he has occasionally noted some difficulty in swallowing and particularly in drinking liquids. His speech also became somewhat drawling and hesitant in character. His wife noted the onset of a peculiar staring, fixed facies. His physical examination was essentially negative.

Neurological examination revealed diminished sensation over the left ophthalmic division of the trigeminal nerve with a diminished corneal reflex of the left eye. On entry in the hospital there was no evidence of nystagmus, though after a short period of time nystagmus appeared intermittently. His palatal and pharyngeal reflexes were diminished, and there was a paresis of the left side of the tongue. His tongue protruded slightly to the left and had a very marked tremor. Upon walking he staggered from side to side, more to the left than the right, and he further presented the usual signs of cerebellar involvement. Pyramidal tract irritation existed to a slight degree in that the deep reflexes of the right leg were slightly more active than the left. No pathological reflexes existed. Spinal puncture was performed which revealed a normal spinal pressure and the serology was also entirely normal. Blood, urine and Wassermann were entirely negative, as were X-rays of the skull.

Clinical Course.—The patient was given 50 per cent. glucose intravenously three times a day, with moderate dehydration therapy. Rather quickly his corneal reflexes returned, the sensation of the ophthalmic division improved, and his gait became less ataxic. His tongue still protruded to the left, his palatal and pharyngeal reflexes remained diminished, but his hesitant speech subsided. Nystagmus, however, though not present at all times could be more frequently elicited.

March 23, 1931, Dr. Isaac Jones performed a vestibular test, and also tested his hearing with an audio-amplifier. From these studies, he concluded that the auditory chart shows slight conductive defect. Cochleas practically normal. No evidence of any marked effect upon the cochlear portion of either internal ear by any toxæmia, except that we note the whispered voice is not heard well in either ear, and there is a lowered percentage for the upper tones. This, however, is to be considered as a rather slight cochlear defect, because the upper limit is normal in each ear.

Vestibular chart shows a vertical nystagmus upward, spontaneous, even when the patient looks up only very slightly. This would appear to be pathognomonic of brain-stem lesion. He has fairly good response in both nystagmus and motion-sensing after turning, but no pallor, sweat or nausea.

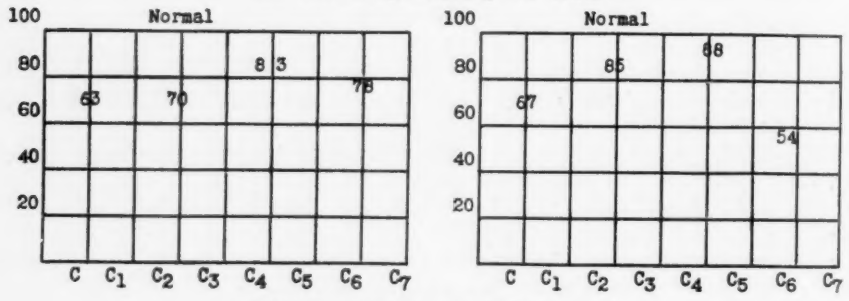
Caloric tests: Douching right ear gave prompt nystagmus and yet prolonged douching for four minutes produced no pallor, sweat or nausea whatever, and very little motion-sensing. This, like the spontaneous vertical nystagmus upward, suggests posterior fossa lesion. The right vertical canals produced some rotary nystagmus, but the

I. Amplifier.

Voice, confused ____, distinct ____. Voice, confused ____, distinct ____.

Whisper, percentage hearing X. Whisper, percentage hearing 58%.

II. Percentage Hearing for Tones.



III. Upper Limits of Audibility.

15,000 d.v. 14,000 d.v.

IV. Bone Conduction.

128 85, 256 97, 512 97. 128 85, 256 94, 512 94.

main element was horizontal. In addition the right horizontal canal showed not only a large horizontal nystagmus to the left, but a tendency to conjugate deviation to the right. Duration of the nystagmus was only one-fifth normal. Douching the left ear produced almost no nystagmus after four minutes from the vertical canals, and yet there was a good horizontal to the right from the horizontal canals when the head was put back. Duration one-fifth normal. No motion-sensing; no pallor; no sweat; no nausea. The right arm past-pointed properly to the left, but the left arm past-pointed in the wrong direction repeatedly three inches to the right. It would appear that there is a lesion of the central vestibular pathways in the brain-stem, subtentorial.

During the month of April, the patient had periods of improvement, and as a whole, appeared very much better than at the time of the first examination, though from time to time there were short intervals wherein his symptoms were exceedingly disturbing. During the month of May, his staggering gait became worse and the difficulty in swallowing increased. At this time a ventricular estimation was carried out which revealed equal- and normal-sized ventricles. No evidence of increased intracranial pressure existed. Following the ventricular drainage very marked improvement was again noted. In the early part of June, the patient showed improvement rather

than progression of symptoms. His neurological signs were not constant, but varied from time to time. The patient's illness was diagnosed a posterior fossa tumor, but in view of his improvement surgery was postponed. During the author's absence, the patient was operated on in another clinic with a subsequent fatality.

Through the kindness of Dr. V. L. Andrews, pathologist to the Hollywood Hospi-

TESTS OF THE VESTIBULAR APPARATUS

Performed by Doctor I. H. Jones

Surname | First Name | Middle Name | Date 3-17-31

CASE NO. 347-52-31

SPONTANEOUS

NYSTAGMUS

Straight ahead distinct wavering

Looking straight ahead

Looking to RIGHT

Looking to LEFT

Looking UP Slight Degree Vertical

Looking DOWN none

POINTING

	RIGHT ARM	LEFT ARM
Nystagmus		
Vertigo		
Past-pointing		
Falling		
Romberg		
Head to right		
Head to left		

TURNING

no pallor, sweat, nausea

To RIGHT →		
Duration 15Sec.	Nystagmus	to / to
Amplitude good	Motion sensing	
	Past-pointing	
	Pallor Sweat	
	Nausea	
To LEFT ←		
Duration 24Sec.	Nystagmus	to / to
Amplitude good, wide rather oscillatory	Motion sensing	
	Past-pointing	
	Pallor Sweat	
	Nausea Vertigo 12	

CALORIC

Prompt nystagmus, yet prolonged douching produces no pallor, sweat, nausea, slight motion sensing

Douche RIGHT ↶ plus horizontal			
After min. sec.	Nystagmus slight leaning to right	2½ to R	1 to R
Amplitude	Motion sensing		
	Past-pointing very little		
Total: min. sec.	Pallor no Sweat no		
Horizontal some rotatory element. Suggest central lesion.	Nausea no		
	Vertigo present		
Head Back →	Falling, some swaying		
Amplitude	Duration: One-fifth normal	1 to R	½ to R

Large horizontal to the left

Tendency to conjugate deviation to right

about % function

Douche LEFT ↷	No pallor		
After min. sec.	Nystagmus	T to R	T to L
Amplitude	Motion sensing		
Occasional slight rotatory	Past-pointing		
Total: min. sec.	Pallor no Sweat no		
	Nausea no		
Head Back ←	Vertigo not present		
Amplitude	Duration: One-fifth normal	3 to L	3 to R
		1 L	3 R

about % function

posterior-fossa-subtentorial, brain-stem.

tal, the specimen was procured. *Gross Pathology.*—The calvarium and meninges were entirely normal. The hemispheres were normal, the ventricles showed no signs of dilatation. In the posterior fossa, on the left side, was seen an elongated mass, about the size of an English walnut, reddish-brown in color, with an irregular surface and cystic in character. Upon removal, the cyst was ruptured and a brownish colored

fluid exuded. The tumor compressed the pons and indented the cerebellum. (Fig. 1.) Here may be noted also the large central cyst. By careful dissection, the origin of

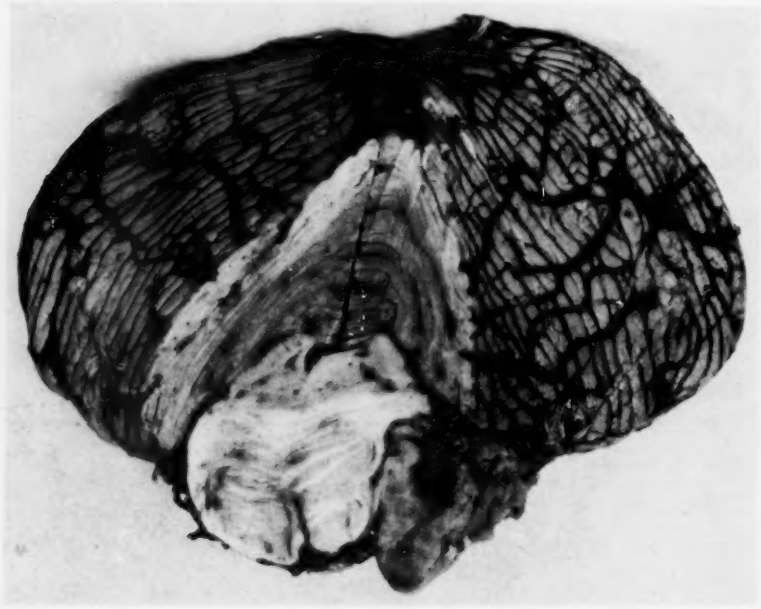


FIG. 1.—Transverse section through the pons and cerebellum showing the cystic tumor distorting the pons and cerebellum.

this tumor was traced to the sensory root of the fifth nerve. The cranial nerves from the fifth to the twelfth were also compressed by this tumor. (Fig. 2.) A pathological

FIG. 2.—Showing attachment of the root of the fifth nerve to the capsule of the tumor.

report by Dr. V. L. Andrews and Dr. Wilder Penfield indicated we were dealing with a perineurial fibroblastoma.

Virchow,[10] in 1863, divided these tumors into the true neuromas and the false neuromas. Sternberg,[11] in 1900, and Henschen,[12] in 1916, described these tumors arising from the acoustic nerve. Verocay,[16] in 1908, developed the theory of neuronomas and described several cases wherein these tumors occurred in multiple locations. Antoni[14] discussed these tumors with particular attention to their involvement along the spinal nerves. Verocay[15, 16] suggested the term, "neurinoma" because he considered the fibres to be nerve fibres, and the cells to arise from the sheath of Schwann which he felt were capable of producing nerve fibres.

It is generally accepted that these tumors arise from the sheath of the nerve. There are, however, two different nerve sheaths on each peripheral

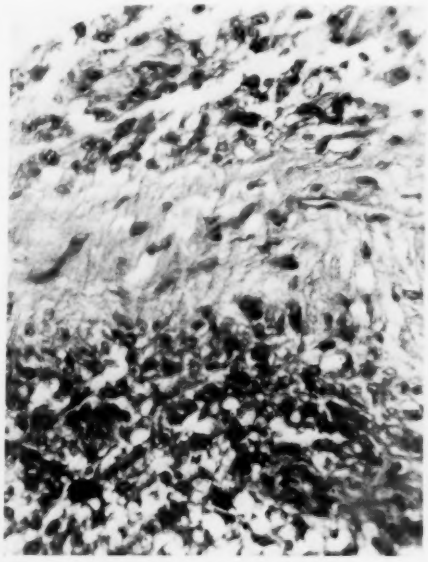


FIG. 3.—Palisading and whorl formation of the nuclei. The fibres between the palisading is characteristic. (A. H. Zeiler.)

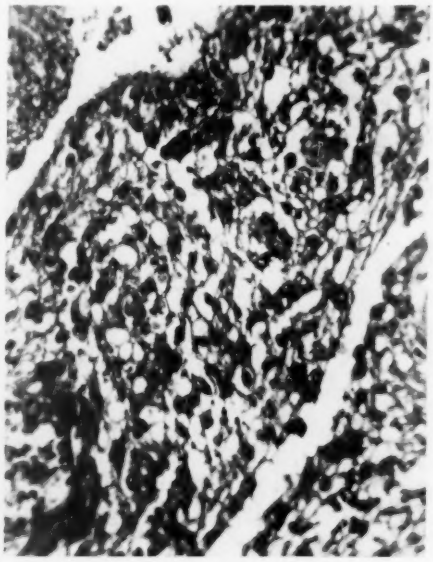


FIG. 4.—Degeneration and cystic areas. (A. H. Zeiler.)

nerve and each nerve root—the sheath of Schwann, which is of ectodermal origin, and the endo- and perineurium which are formed of connective tissue.

Mallory,[17] in 1920, concluded that the cell formed fibroglia and collagen fibros as well as elastic tissue, and he therefore termed these tumors, "perineurial fibroblastoma." Rhoads and van Wagenen,[18] as well as Penfield,[8, 9] upon further studies agreed with the terminology proposed by Mallory and at the present time these tumors are considered as "perineurial fibroblastoma." These tumors may be found throughout the body, along the peripheral nerves, spinal roots, the cranial nerves, the most common being the acoustic. Occasionally the fifth, as in the forgoing case, the third and twelfth nerves are involved. Antoni has pointed out that these tumors are more frequent along nerve roots than along peripheral nerves. Grossly, these tumors are encapsulated, solid or cystic, and have irregular uneven surfaces. The cystic cavities are filled with a yellowish-brown fluid and a certain degree of vas-

cularity exists. The fibres of the nerve may be observed in the capsule of the tumor.

Microscopical examination reveals the presence of palisading of the nuclei. Occasionally whorl formation occurs. The nuclei may be elongated or curved. (Fig. 3.) Within the nuclei the chromatin network is loose and large nucleoli may occur. Long, parallel fibres are clearly brought out by the methods for staining collagen, such as Laidlaw's connective-tissue stain, Rio-Hortega's silver carbonate, Foot's and Perdreau's methods. In the degenerative areas cysts are found and here are located phagocytic cells laden with fat. (Fig. 4.) Degenerative fibroblastoma may resemble nerve cells.

A careful search of the literature has revealed only three cases which simulate the above case reported. As mentioned previously, this seems an unusually small number of cases and in all probability other cases must be reported under other captions.

CASE I.—(Reported by Klebs[19] and Petrina[20] in 1874.) Male, servant, forty-six years of age, was admitted August 23, 1874. For nine years he had attacks of vertigo, which occurred at intervals. About six months ago he developed an unsteady gait with weakness of the left leg and pain in the ophthalmic division of the left fifth nerve. He developed an exophthalmus and strabismus of the right eye. Deafness of the left ear was also apparent, and there was a very slight paresis of the left side of the face. His gait was unsteady, with a tendency to a wide base and a deviation to the right. He had some urinary difficulties; developed a loss of vision; had headaches and choked disks. The post-mortem examination by Doctor Petrina showed the cranium well supplied with diploic vessels, thin bones, the dura tense and the vessels distended with blood. The convolutions were flattened on the brain surface and under the tentorium a large quantity of fluid was found. On the side of the left cerebellar hemisphere was seen a mass, the size of a walnut, compressing the pons and measuring two and one-half by five centimetres. The surface of the tumor was grayish-red in color and studded with humps. It was very vascular and partly gelatinous. Both of the lateral ventricles were widely dilated. The fourth ventricle was asymetrical. In the gasserian ganglion could be seen some extension of nerve fibres from the tumor mass which continued forward to involve the peripheral divisions of the trigeminal nerve. The motor portion of the trigeminus was not involved. The peripheral portion of the trigeminal was not involved.

Microscopical examination revealed nerve fibres of different calibre, which possessed to a greater part medullary sheaths. They intra-crossed in all directions. The diagnosis was a neuroma of the root of the trigeminal nerve.

CASE II.—(Reported by Marchand[21] in 1907.) A male, aged fifty-six years, presented a rather lengthy history of intermittent signs of cerebellar pontile involvement, with definite symptoms referable to the sensory division of the fifth nerve, and very little indication of eighth nerve pathology.

The autopsy revealed a tumor the size of a small walnut, situated in the posterior fossa and continuing into a slightly large gasserian ganglion. This tumor extended forward causing a thickening of the second and third branches of the trigeminus, but preserving the motor branch. It appeared as if this tumor originated from the respective nerve sheaths, and consisted of spindle-form cells with longitudinal nuclei and sparse nerve fibres. In general this presented some of the aspects of a round-cell sarcoma. Diagnosis: Neurocytoma.

CASE III.—(Reported by Altmann[22] in 1928.) A male, smelter, aged fifty-five, entered hospital October 25, 1926. In April, 1926, the patient complained of vertigo,

headache, loss of memory and diminished vision. Neurological examination revealed the horizontal nystagmus, with rotary components stronger on the right side. There are a few rotary contractions on looking upward. The left corneal reflex is diminished, as well as a diminished sensation in the second and third division. There was a slight left-sided motor paresis, and the hearing was diminished slightly on the right. On bending to the right there was slight weakness. A tumor of the posterior cranial fossa was suspected; radiation therapy was carried out. This improved the patient greatly. The headaches and vertigo almost disappeared, facial paresis improved, as well as the sensation of his face improved. January 8, re-admitted for second series of radiation therapy. At that time the Babinski was positive on both sides, Oppenheim slight, had a tendency to fall backward in the Romberg position, often to the left, gait slightly staggering but more to the right; turning produced an excess of vertigo. Following the radiations the findings January 15 showed a nystagmus more on the right, head slightly held to the left, tremor of the right upper extremity and a bilateral intention tremor. The left hand showed cerebellar disturbances; the right leg showed pyramidal tract signs. Following radiation his hearing improved as well as the cerebellar symptoms. Within several weeks, however, he again developed further symptoms, particularly those of dementia, disorientation and poor judgment. He developed pyramidal tract signs on the right. March 3, 1927, he developed a hypostatic pneumonia and died. The diagnosis rested between a cerebellar tumor, an eighth nerve tumor, vascular disease, and encephalitis.

Autopsy revealed on the left half of the pons an egg-shaped cystic tumor, large, irregular and nodular, measuring 5.2 by 0.5 centimetres, compressing the cerebellar hemispheres and well circumscribed. The cranial nerves from the sixth to the twelfth were compressed. The trigeminal root was incorporated in the tumor. A section of the tumor showed it to be composed of multiple minute cysts which were filled with a yellowish-reddish fluid. *Histological Examination.*—A diagnosis of neuroma with degenerative changes was made, which consisted of softening the formation of the protoplasmic net work, hyalanization and hæmorrhage, the tumor developing chiefly in the trunk of the trigeminus nerve without affecting the motor portion; part of the tumor invaded the gasserian ganglion.

SUMMARY

From the study of the reported case, together with the three additional cases collected from the literature, it appears as if a clinical syndrome of perineurial fibroblastoma of the fifth nerve may be deducted. Trigeminal pain is absent because the ganglion itself is not involved. Evidence of trigeminal involvement is a consistent and early symptom and is exemplified by a diminished or absent corneal reflex, as well as anæsthesia over the trigeminal distribution, particularly the ophthalmic division. With encroachment upon the cerebellum signs become apparent. Further pressure upon the medulla and pons results in cranial nerve symptomatology and pyramidal tract signs. The history is of long duration with a late development of intracranial pressure. Periods of remission are characteristic in all these cases. The vestibular tests and audio-amplifier are helpful in ruling out tumors in other areas.

Tumors arising in the ganglion itself usually have pain as well as anæsthesia in the trigeminal division. Cerebellar signs are extremely late and only occur with extension beneath the tentorium. Perineurial fibroblastoma of the eighth nerve may be readily differentiated from these tumors by a loss of

hearing and a lengthy history of tinnitus. Vestibular tests are diagnostic of these tumors (Jones,[23] Grant and Fisher,[24] Glaser and Fisher[25]). Meningiomas situated in the angle may be differentiated by the sequence of symptoms. However, if such a tumor should first involve the fifth nerve, great difficulty would be encountered in a differential diagnosis. Meningiomas generally have a more progressive course and are not subject to remissions. Gliomas of the pons and medulla are readily differentiated by the bilaterality of symptoms and the definite vestibular findings indicating destruction rather than pressure. In tumors of the cerebellum the sequence of events is that of cerebellar symptoms first and extra cerebellar symptoms last; in addition, the vestibular tests are of great value.

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BRAIN LESIONS AND DUODENAL ULCER

REPORT OF TWO CASES

By Francis C. Grant, M.D.

of Philadelphia, Pa.

FROM THE NEUROSURGICAL SERVICE OF THE HOSPITAL OF THE UNIVERSITY OF PENNSYLVANIA, PHILADELPHIA, PA.

In 1841, Rokitansky[1] suggested that ulcerative processes of the stomach might be due to dysfunction of its nervous mechanism. Some twelve years later, Virchow[2] stated that ulcer of the stomach or duodenum was primarily due to pathology developing in and inherent to the area in which the ulcer is situated. Virchow's reputation together with the apparently greater plausibility of his explanation for the cause of ulcer led to its general acceptance. But when Virchow's theory was tested experimentally in animals, difficulty was found in producing a local lesion, chronic in nature, at all comparable to gastric or duodenal ulcers seen in man, by direct attack upon the stomach or duodenum.

A review of the voluminous literature describing attempts to produce these lesions by direct attack on the stomach or duodenum shows clearly that the chemical action of pepsin-hydrochloric-acid (of the concentration found in pure gastric juice) can by itself alone produce a typical chronic progressive ulcer. But the alterations in the anatomy and physiology of the stomach and duodenum, necessary to permit pure gastric juice to contact these areas for long periods unneutralized by biliary, pancreatic, or intestinal secretions, are so marked that the propriety of claiming that an ulcer, arising under these conditions has precisely the same etiology as a similar lesion in man appearing in the absence of such induced changes, seems open to criticism. In man under normal anatomical conditions another factor must exist which affects the gastric mucosa, rendering it more susceptible to erosion and ulceration.

Much evidence has recently been produced to suggest that the sympathetic and parasympathetic nervous mechanism might supply this missing factor for the cause of ulcer. In 1845, Schiff[3] showed that a unilateral lesion of the optic thalamus and cerebral peduncle in dogs and rabbits would frequently result, in a few days, in erosion of the stomach and at times in perforation. In 1875, Brown-Sequard[4] demonstrated that injury to the cerebral cortex could produce a chronic and perforating ulcer. Ebstein's[5] contemporary experiments showed that unilateral punctate lesions close to the anterior corpora quadrigemina would cause ulcerative erosions of the stomach and duodenum. In 1894, Preuschen and Pomorski[6] induced gastric hæmorrhage and erosions by artificial lesions in the cerebral crus, corpora quadrigemina, pons and fourth ventricle. In 1909, Gibelli[7] showed that bilateral adrenalectomy was followed by gastric and duodenal erosions. Durante,[8] in 1912, sectioned the median and minor splanchnic nerve on either side and produced similar results. Mogilnitsky and Burdenko,[9] in 1925 made bilateral hypo-

thalamic punctures which were followed by gastric and duodenal lesions acute and chronic. Beattie, Brow and Long,[10] in 1932, reported that careful electrical stimulation of the tuber nuclei, avoiding any spread of current, would result in increased motility and secretion of the stomach. If the stimulation was continued for a sufficient time fine patches of hyperæmia appeared in the mucosa. Free hydrochloric acid and pepsin were noted in this secretion. Light, Bishop and Kendall[11] have recently shown that the injection of pilocarpine into the ventricle of a rabbit will produce increased intestinal peristalsis and gastric erosions.

Cushing[12] has reported eleven cases of intracranial lesions accompanied by gastric lesion. In six of these patients a tumor lay in the cerebellum, in five involving the vermis and roof of the fourth ventricle, while the sixth, a large basilar aneurism, lay anterior to the brain stem. In five of these subjects acute erosions developed resulting in perforation of the viscus. The sixth, a child in whom a mid-line cerebellar tumor was verified, lived for two years and at autopsy a chronic duodenal ulcer was found. In two cerebral tumors, an olfactory groove meningioma and a hypernephroma metastasizing to the right parietal lobe from the left kidney, acute gastric erosions with hematemesis were a contributing cause of death. Of two cases of malignant hypertension, one developed a sudden abdominal crisis and laparotomy was performed with closure of a ruptured gastric ulcer; while the other died abruptly with hyperthermia and autopsy revealed multiple recent gastric ulcers. The eleventh case had a third ventricle tumor verified by a ventriculogram. The tumor proved radio-sensitive and he was benefited by röntgen-ray therapy. Later he reappeared with gastric symptoms and gastro-intestinal röntgen-ray studies revealed unmistakable evidence of a gastric ulcer. In the course of a second series of röntgen-ray therapy for his brain tumor all symptoms of his duodenal ulcer disappeared.

Within the last year two cases have passed through the neurosurgical department of the University Hospital with verified mid-line cerebellar tumors, an ependymoma and a spongioblastoma unipolare. Following apparently successful surgical treatment and in one case when the child was considered well on the road to recovery, symptoms of gastro-intestinal bleeding occurred which eventually led to death. Because of the circumscribed nature of the lesion in one instance and the further evidence thus established of the control of the diencephalic centers over the proper functioning of the gastro-duodenal mechanism they are reported.

Case I.—R. C., aged ten, white. This boy was apparently well until a year ago when blurred vision developed. During the past year his visual loss has gradually increased and he has had headache and vomiting every week or two. Twice dizzy spells occurred which caused him to fall down without apparent cause. Slight mental retardation has been noted.

P.M.H. No gastro-intestinal disturbance up to time of onset of present symptoms. P.E. Normal-appearing boy of ten years, with a very large head, fifty-eight centimetres in diameter. Normal measurement for this age is fifty-one centimetres. N.E. (1) Vision poor in both eyes. (2) Bilateral choked disk, three to four diopters. (3)

Slight dysdiodokokinesia, dysmetria and moderate hypotonia in all extremities. (4) Pendulous knee-jerks right and left. (5) Cracked-pot sound on percussion over the skull.

Laboratory.—Blood count, urine, Wassermann negative. X-ray.—Possible increased intracranial pressure. Eye Examination.—Visual fields show left homonymous scotomata. *Operation.*—March 15, 1933, Doctor Grant. Suboccipital craniectomy. On retracting the cerebellar tonsils over the lower end of the fourth ventricle, what was supposed to be a tumor in that region was encountered, so that a section through the vermis was made. Prior to the section of the vermis, 1½ centimetres of indigocarmine had been injected into the right lateral ventricle. It was noted that none of the fluid appearing from the fourth ventricle was tinted with the dye. Exposure through the vermis showed the entire fourth ventricle but failed to expose the tumor. It should

FIG. 1.—Brain at autopsy, Case I, showing tumor (T) involving colliculi. Note marked distention of third ventricle.

be stated that the fourth ventricle did not seem to be dilated. A good view of the aqueduct was obtained and because no fluid was passing through it, the eye of a small probe was passed up through the aqueduct. This allowed the immediate escape of four or five cubic centimetres of deeply blue fluid. A small bayonet forceps was then passed closed through the orifice and allowed to open in it. This was followed by the escape of ten or fifteen cubic centimetres more of bluish fluid. The aqueduct was dilated in this way in the twelve and six o'clock planes and in the nine and three o'clock planes. This was followed by a free flow of fluid. On passing the forceps through the aqueduct there was nothing to suggest that the patient had a third ventricle tumor. Clinically no evidence existed of the presence of tumor in the neighborhood of the pineal gland. Inasmuch, as for the time being at least, cerebrospinal fluid circulation had

been restored, hemostasis was completed and the wound closed in layers as usual, without drainage.

The child's condition following operation was very poor, and he was given two transfusions of 200 cubic centimetres each. Seventy-two hours after operation he began to have tarry bowel movements. These continued with increasing frequency until he died March 22, 1933 at 6.35 A.M. on the seventh post-operative day. He was given two more transfusions on March 21, 1933 of 250 cubic centimetres each. His final post-operative course was marked by a temperature of 107°, a pulse of 160 and respirations of 40 to 60.

POST-MORTEM.—*Gross Neuropathological Report.—The Brain.* The hemispheres were cut in coronal sections. This disclosed a very marked hydrocephalus of all the ventricles except the fourth which was moderately dilated. The dilatation of the ventricular system was equal on the two sides.

The pineal gland was enlarged. It measured 4 millimetres in diameter and was

FIG. 2.—Duodenal ulcer found at necropsy in Case I. Pyloris (P). Duodenum (D).

cystic. The centre contained a yellow fluid. It did not appear to be tumorous. There was an operative incision through the vermis into the fourth ventricle. The aqueduct of Sylvius was apparently occluded before operation. This was evidenced by a questionable proliferation of the ependymal cells which had formed an obstruction to the flow of fluid.

The colliculi represented the most interesting part of the picture. The transverse intercollicular groove was completely lacking. The left colliculus was one-third again as large as the right. When cut in transverse section the enlargement of the left colliculus seemed to be due to a round, white, hard tissue which was not definitely outlined. The same condition existed on the right. These masses located in the colliculi extended medially to compress the aqueduct and inferiorly to a short distance below the level of the aqueduct. They had no distinct outline. They were avascular, white and extremely tough.

SUMMARY.—A large, hydrocephalic brain with partial occlusion of the aqueduct of

Sylvius. Questionable ependymal proliferation of the cells lining the aqueduct of Sylvius. An enlarged cystic pineal gland. Two apparent tumors of both the right and left colliculi, the one on the left being the larger. An operative incision through the vermis extending into the fourth ventricle.

Microscopical Neuropathological Report.—The Brain. A section was taken through the mid-brain. The iter is practically occluded. Only a narrow, slit-like space remains of the aqueduct. Around it is a neoplastic process which involves the tissues around the iter and spreads up and down in the mid-line.

Within this area are ependymal-like pockets which are probably normal and represent out-pouchings of the iter. The tissue around the iter is quite cellular with the cells running in many different directions. One sees streams of cells and others cut in cross-section. Around the iter the cells have a radial appearance but this is lost farther away. The cell nuclei are large, oval, elongated and often indented. The cytoplasm is frequently seen arranged in polar fashion, with a stout polar process. Occa-

FIG. 3.—Photomicrograph through aqueduct in Case I. Blockade of aqueduct and involvement of gray matter in walls of aqueduct by tumor shown. Weigert stain x 75.

FIG. 4.—Photomicrograph of a more cephalad section than Fig. 3, in Case I. Bilateral involvement of periventricular gray matter by tumor shown. Weigert stain x 75.

sional astrocytes are seen. Among the cells are many stout fibrils some of which are connected with the cells. The colliculus of one side is invaded by tumor. Diagnosis.—Spongioblastoma polare.

Stomach.—The stomach is normal in size, shape and thickness. The mucosa is somewhat smoother than normal as a result of autolysis. It is of a pale, pink color with a few tiny dilated venules visible over the crests of the rugæ. The pylorus is normal. There are a few cubic centimetres of colorless mucoid fluid in the lumen.

Duodenum.—The wall is of the usual thickness. The mucosa is velvety and the rugæ of the usual shape. The mucosa is of a rather dark pink color with numerous tiny dilated venules visible in its depths. About 2 centimetres below the pylorus on the posterior wall of the duodenum, where the pancreas is adherent to it, there is a shallow ulcer about 1 centimetre in diameter. The base of this ulcer is covered by a thin layer of tenacious dark yellow mucus which is scraped off with difficulty leaving a light pink granular surface in the centre of which is a tiny pit about 1 millimetre in diameter and 0.5 millimetres in depth. The edges of this ulcer are low and soft

with no palpable induration or visible discoloration. The lumen of the duodenum contains a small amount of light yellow chyme.

Jejunum and Ileum.—Usual size, shape and thickness. Mucosa of light pink color and velvety texture. Valvulæ conniventes normal. Peyer's patches of lower ileum slightly hyperplastic.

Colon.—Normal size, shape and thickness. Mucosa normal. Lumen contains a small amount of dark, gray fluid which has a creamy consistency.

Suprarenal glands were grossly entirely negative.

CASE II.—M. F. Admitted University Hospital, May 15, 1933 with chief complaint of headache and vomiting. Vision in O. S. was impaired. Pain also noted in neck and arms. P.M.H. No gastro-intestinal symptoms until onset of present illness. N.E. (1) Positive Romberg. (2) Dysmetria with left hand. (3) Right lateral rectus palsy. (4) Choked disks of four diopters. (5) Sluggish right pupil. (6) Areflexia.

X-ray evidence of increased intracranial pressure and convolutional atrophy. Ventriculogram. May 29, 1933. Bilaterally dilated lateral ventricles and dilated third ventricle without mid-line shift point to a cerebellar lesion.

Operation.—May 29, 1933. Suboccipital craniectomy. Mid-line cerebellar tumor (ependymoma on pathological examination) found and section removed for study.

Course.—Convalescence uneventful. Discharged June 13, 1933 with little bulging at site of decompression. Recommended to return in six weeks for further operative procedure. Interval note (June 13, 1933 to September 5, 1933).—Remained symptom-free until August when headache and vomiting returned.

Second Admission.—September 5, 1933. Returned for removal of tumor. Neurological and physical examinations the same as on first admission. Laboratory.—White blood cells, 7,900; Hemoglobin, 84 per cent. Urine, negative.

Operation.—September 15, 1933.—A suboccipital craniectomy was performed and an ependymoma involving the vermis and extending down into the fourth ventricle and into the right cerebellar hemisphere was exposed and radically removed by Doctor Grant.

Post-operative Course.—The patient did nicely until the evening of September 22, 1933, one week after operation when he passed a grossly bloody stool. Hemogoblin, 78 per cent.; White Blood Cells, 24,000. On advice of surgical consultant condition treated as for bleeding ulcer. Given small daily transfusions but patient continued to pass loose tarry stools and frank blood-clots. Intravenous drip (five per cent. glucose) started September 26, 1933. Patient expired September 27, 1933 at 6.15 A.M. on the twelfth post-operative day.

POST-MORTEM.—*The Brain.*—This was quite œdematous. On section there was noted moderate degree of internal hydrocephalus, which was greater in the inferior than in the anterior or posterior horns, of the lateral ventricles. Third ventricle and iter dilated. The brain showed active post-mortem change with the typical Swiss-cheese appearance.

Filling the fourth ventricle is a tumor which is firmly adherent to the floor of the medulla and which seems to extend into the right cerebellar hemisphere. It is uncertain whether this is the case because of the operative incision in the right cerebellar hemisphere. Despite the removal of a large bit of tumor the ventricle still seems entirely filled with neoplasm. The latter has a reddish, fleshy appearance and seems to infiltrate the floor of the fourth ventricle. It cannot be pulled away from it. The left cerebellar hemisphere and vermis seem not to be invaded.

Abdominal Cavity.—There are about 500 cubic centimetres of dark brown, foul-smelling fluid in the peritoneal cavity. This fluid has a distinctly bloody appearance

in the right upper quadrant, where close examination reveals extensive necrosis of the jejunum, the mesentery and the omentum. This necrosis is obviously due to digestion by gastric fluid leaking from a large perforation in the first portion of the duodenum. The jejunum is completely destroyed in some areas, the lumen communicating with the abdominal cavity through ragged openings. The gastrohepatic ligament is partly destroyed. There is a zone of discoloration about three centimetres in width over the dome of the liver where the gastric fluid has seeped between the liver and diaphragm. The under surface of the diaphragm is markedly digested and it is completely destroyed in several small areas. The colon and ileum are of a dusky purple color due to blood in the lumen. The stomach and bowel above the jejunal erosions are pale and collapsed.

Stomach.—The wall is of normal thickness and of good tone. The mucosa is pale and velvety and thrown into pronounced rugæ. The lumen contains large quantities of mucus and a small amount of partly digested blood.

FIG. 5.—Tumor removed from Case II, showing fingerlike projection extending up into aqueduct.

Duodenum.—Normal size and shape. Just below the pylorus there is a deep irregular ulcer with flat edges. This ulcer lies on the upper and posterior aspects of the first portion of the duodenum and measures about one by two centimetres. There is a large gaping perforation about 0.8 centimetre in diameter in the upper aspect of the ulcer which communicates freely with the peritoneal cavity. There are no adhesions to surrounding structures. The lumen of the duodenum is empty except for a little clear mucus and a few flecks of partly digested blood. The mucosa below the ulcer is pale and velvety.

Jejunum.—The upper portion is of normal size and thickness and the mucosa is normal. At the lower portion of the jejunum there are numerous, irregular areas of necrosis with complete destruction of the wall in places. The mesentery in these regions is partly or completely digested. The necrotic areas in the bowel allow free communication between the lumen and the peritoneal cavity. These lesions are obviously the result of digestive action from without rather than within the gut. *Ileum.*—The entire bowel below the necrotic areas is filled with clotted and partly digested blood. The mucosa is stained by blood but shows no other lesion. *Colon.*—Normal size, shape and thickness. Lumen filled with partly digested blood. Mucosa blood-stained but otherwise normal. *Suprarenal Glands.*—These structures are entirely normal on gross examination.

Microscopical Report.—Stomach.—The muscularis is of normal thickness. The mucosa is well preserved and shows no lesion. *Duodenum.*—The section from the edge of the ulcer shows it to extend cleanly through all the coats as though punched out. There is a slight degree of leucocytic infiltration in the adjacent tissue but no fibrosis.

These two cases correspond closely to those described by Cushing. However the brain lesions are dissimilar in type and character although the effect

upon the gastroduodenal region was much the same. That either of these duodenal ulcers could have been produced by agonal or post-mortem changes is unlikely because blood appeared in the stools seventy-two and ninety-six hours antemortem. Furthermore, at autopsy there was no evidence of autodigestion of stomach or duodenum in either case. In one brain a circumscribed lesion surrounded the iter and involved both colliculi. In the other neither of these areas was implicated, the tumor appearing in the roof and sides of the fourth ventricle and adjacent cerebellum. The lesion in the colliculi might conceivably have involved directly the posterior hypothalamic nuclei controlling the sympathetic and parasympathetic nuclei, the tumor in

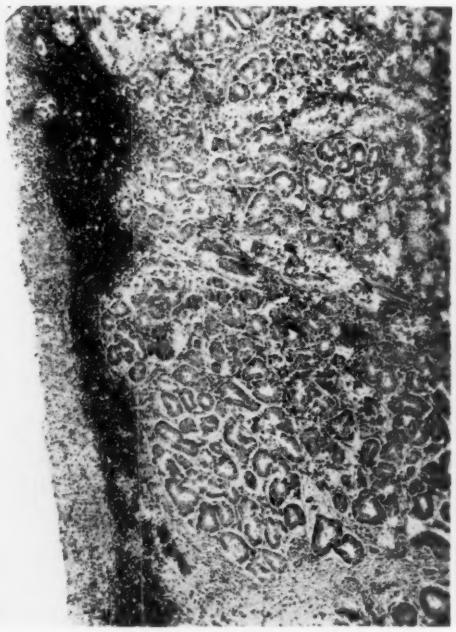

FIG. 6.—Photomicrograph of gastric erosion found at necropsy in Case II. H. and E. x 75.

FIG. 7.—Photomicrograph through edge of perforated ulcer in Case II. H. and E. x 75.

the roof and sides of the fourth ventricle, efferent fibres running from these centres. In one instance the centres, in the other their efferent pathways seem to have been damaged.

In animals, under experimental conditions involving gross derangement of the normal anatomy and physiology of the gastro-intestinal tract, pure unneutralized gastric juice can be brought into continuous contact with the gastro-intestinal mucosa. Chronic ulcers quite comparable to those occurring in man may thus be produced. By interference with the carefully balanced sympathetic and parasympathetic mechanism, by adrenalectomy, by section of the splanchnic nerves, or by stimulation or destruction of centers in the midbrain controlling this mechanism, erosions and ulcerations can be produced in the stomach and duodenum, though few of the lesions are strictly

comparable to chronic peptic or duodenal ulcers seen in man. Furthermore, the appearance of such gastroduodenal lesions in experimental animals is by no means a constant finding. Bazett and Penfield[13] never found them in their chronic decerebrate cats. Keller[14] reported only eight such lesions in a series of sixty dogs with gross damage to this region, although Light[11] states that following intraventricular injection of pilocarpine in rabbits he always found erosions of the gastric mucosa. Following the removal of brain tumors from areas close to the centres controlling the sympathetic and parasympathetic mechanism or their connecting pathways, a relatively small number of patients develop gastro-intestinal complications. None of the sixteen cases of verified third-ventricle tumors removed at operation by Dandy[15] showed

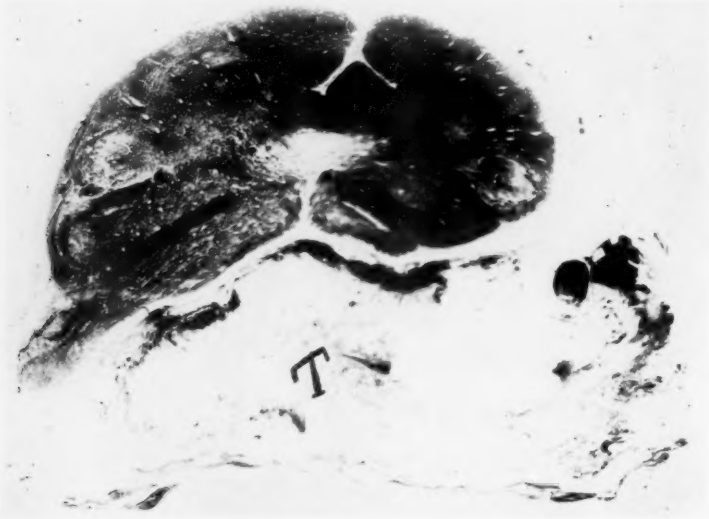

FIG. 8.—Photomicrograph of cross-section through medulla and tumor in IV ventricle, Case II. Involvement of medullary substance shown. Weigert stain x 75. (T-tumor.)

gastro-intestinal symptoms. The great majority of patients with mid-line or other cerebellar tumors show no such effects following removal of the mass.

What is the mechanism of ulcer production? The evidence, that a free play on the mucosa of gastric juice in an unneutralized state is an important factor, is definite. Light[11] showed that following pilocarpine injection into the ventricles, vasoconstriction of the finer blood-vessels running to the tips of the gastric papillæ occurred. The action of the free acid in the gastric juice in contact with a mucous membrane with its resistance to autodigestion lessened by constricted blood-vessels and impaired circulation, seemed a likely explanation of the erosive action and ulcer formation. But Ferguson[16] demonstrated that pilocarpine injected intraventricularly in monkeys immediately stopped the excretion of free acid and lowered the total acid in the gastric juice.

Rioch[17] has shown that the cell groups of the third ventricle which seem to control in part at least the sympathetic and parasympathetic mechanism have a complex and closely integrated relationship. Unquestionably from clinical and experimental evidence these centres have to do with preserving the integrity of the gastro-intestinal mucosa. But the way in which this control is exercised, whether through the maintenance of a proper blood supply to the mucosa, or the secretion of mucin, which aids in protecting the mucosa from the acid gastric secretions, or by changes in this secretion in time of appearance or its chemical constituents is far from clear. Furthermore, it is striking that although this mechanism might be expected to control the gastroduodenal area as a whole, nevertheless chronic peptic ulcer is a strictly circumscribed lesion resulting from the breakdown of the protective mechanism in a definitely localized area. Although the production of ulcer can no longer be presumed to be due only to local causes, the integrative action or dysfunction of higher vegetative centres necessary to produce such a lesion is still a subject for careful investigation.

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THE MENINGIOMA AS A CAUSE OF EPILEPSY

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A review of 291 cases of verified meningioma was made for the purpose of determining the incidence and character of epileptic attacks. The records of only those patients who had a generalized or focal convulsion were selected. The study included a consideration of the nature of the attacks, the time of onset in relation to the chronology of signs and symptoms of brain tumor and an attempt to correlate the type of epilepsy with the location of the tumor. Since nearly all the patients were operated upon, a study was made of the epileptic attacks following removal of the tumor. This was considered from two standpoints, first, the effect of operation on the attacks in those patients who had epilepsy, and second, the development of epilepsy in those patients who had never had seizures.

In this analysis, the attacks of these cases are described as either grand mal, petit mal, or Jacksonian. For the purpose of discussion it was thought best to divide the Jacksonian seizures into three groups. First are those with attacks of pure motor, second, sensori-motor, and third, sensory spells. Another group of patients who had uncinate attacks are discussed separately.

Epilepsy as a symptom of meningioma is more frequent than is generally supposed. Of the 291 cases, ninety patients, or 30.9 per cent. had epileptic seizures. This figure is practically the same as that given for the incidence of epilepsy in patients with all types of brain tumors. Sargent[1] found 30.9 per cent. with convulsions in a series of 270 cases. Dowman and Smith[2] noted 39 per cent. in 100 verified brain tumors. Parker[3] recorded 21.6 per cent. of 313 cases exclusive of those having petit mal, tonic spasms and Jacksonian epilepsy without loss of consciousness, which would decrease the incidence of convulsions in his cases. The glioma represented the predominating type of lesion whereas the meningioma was infrequent in each group of the above reported cases. According to these studies, epileptic convulsions occurred chiefly in gliomas, the incidence in the meningioma being lower. Our figure of 30.9 per cent. does not substantiate this impression. In fact, it is more significant when one recalls that according to Cushing[4] there are three gliomas to one meningioma.

Of the ninety patients with epileptic seizures, eighteen had grand mal, seven petit mal, and sixty-five Jacksonian seizures. This reveals that most of the patients with epileptic attacks had spells which were Jacksonian.

The location of the tumors in those cases having epileptic attacks is given in Chart I.

In a few instances, because of the size of the growth it was necessary to give the major area of compression, otherwise, the tumor locations are accu-

rate. There were five cases with lesions at the base of the brain, three at the base of the skull, three intra-orbital, and one pituitary, which were not associated with convulsions. These have not been included in the chart.

There are two outstanding facts to be noted. The first is that tumors of the frontal, parietal and temporal lobes are associated with epileptic attacks more often than tumors in other locations. There were 116 patients with lesions in these three regions, eighty of whom had convulsive seizures. The attacks were Jacksonian in character in all the cases with the exception of sixteen with generalized convulsions.

In considering these three regions, the tumors of the paracentral lobule are most frequently associated with epilepsy. There were seventeen growths in this area, fifteen of which caused seizures. Attacks were associated with parietal lobe tumors only slightly less frequently. Of the thirty-four patients with lesions in this region, twenty-six had attacks. Seven of the fourteen frontoparietal tumors caused epileptic attacks. The seizures in all these cases were Jacksonian with the exception of one frontoparietal growth, which was of the grand mal type.

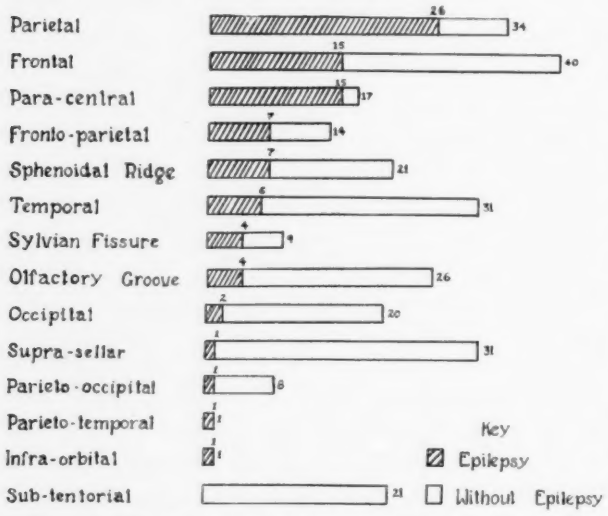

CHART I.—The incidence of epilepsy according to location of the tumors.

The second important fact to be noted is the absence of epilepsy in subtentorial tumors. There were twenty-one patients with lesions in the posterior fossa, not one of whom had epilepsy.

In the nine tumors of the sylvian fissure, there were epileptic attacks in five instances. According to MacRobert and Feinier,[5] tumors of this region attaining considerable size produce such a large area of cortical irritability through interference with the arterial circulation of the cortex as to make the occurrence of epileptiform seizures an almost inevitable consequence. MacRobert and Fienier found that the majority of patients with sylvian-fissure tumors had epileptic attacks. This is not substantiated by the nine cases reported.

The number of attacks varied. Fifty patients gave a history of more than twenty-five seizures whereas the remaining forty had from six to ten attacks. The number of attacks was greatest in those patients who developed convulsions before the onset of other signs and symptoms of intracranial

lesion or where the attacks remained the only evidence of intracranial tumor. The smallest number of seizures in a single case was one, while the greatest was above 100.

Grand Mal.—There were eighteen patients who had generalized convulsions.

Aura.—In ten of the eighteen cases there was no warning of the impending convulsion. Two exceptions had a sufficient number of seizures but never experienced a warning. In the eight patients who gave a history of an aura, the descriptions varied from headaches, blurred vision and mental confusion to an indescribable or exhausted feeling.

Character of Attacks.—Typical grand-mal seizures were present in twelve of the eighteen cases. These patients gave a history of loss of consciousness, generalized clonic movements, frothing at the mouth, usually biting of the tongue and in one, loss of sphincteric control. In the remaining six cases, the seizures were not of a true grand-mal type. Four of these patients had

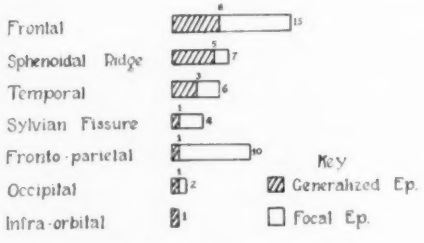

Chart II.—The locations of the tumors causing generalized convulsions in comparison with those causing Jacksonian epilepsy.

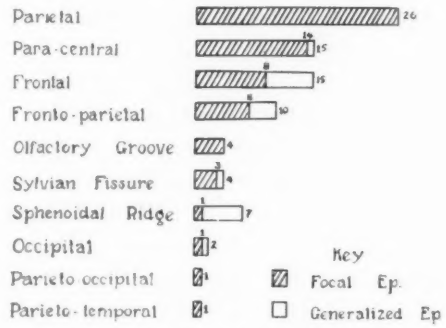

Chart III.—The locations of the tumors causing Jacksonian epilepsy in comparison with generalized convulsions.

a tonic type of convulsion but in other respects the attacks simulated grand mal. The last two patients had attacks which were characterized by shaking movements of the upper extremities and trunk without involvement of the legs. There was no loss of consciousness but one patient became aphasic during the attacks.

Frequency of Attacks.—The number of attacks in any one case with generalized convulsions was small. Nine of the patients had six attacks or less, one of these had a single convulsion. Five had from twelve to twenty-four attacks while the remaining four patients had many. The greatest length of time during which a patient suffered from convulsive seizures was seventeen years, the shortest, ten weeks. Most of the patients had attacks over a period of six months to three years.

A study of the chronology of symptoms in these cases showed that the majority had convulsions as the initial symptom. This was true in eleven of these eighteen cases. In three of these the attacks remained the only sign, while the remaining eight later on developed other signs and symptoms

of intracranial tumor. Grand-mal attacks followed the onset of signs of intracranial disease, unilateral exophthalmos, or gross bony change of the skull in six of the eighteen cases. Three of these did not have attacks until late in the disease. In one case, the seizures began simultaneously with evidence of brain tumor.

Location of the Tumor.—The location of the lesions associated with grand-mal attacks was not uniform, and the tumors in any one region were differently located. However, there were three principal sites for this type of seizure, as seen in Chart II.

The first of these was the frontal lobe with six tumors, of which four were parasagittal, the second was the sphenoidal ridge with five tumors, and the temporal lobe was the third site with three tumors. In the remaining four cases the growths were located in the sylvian fissure, frontoparietal lobes, occipital lobes and infra-orbital region.

Petit Mal.—Petit-mal seizures appeared in only seven of the case records. The attacks were characterized by transitory loss of consciousness which lasted for several minutes. They were of moderate severity as shown by the fact that only one patient fell during an attack. Five of the seven patients had innumerable attacks and premonitory warning of their onset, variously described as a sensation of weakness, faintness or palpitation. The remaining two patients had only four attacks with no subjective knowledge of the seizures.

A survey of the history in these cases shows that four patients developed petit-mal attacks after other signs and symptoms of brain tumor had appeared, the seizures commencing rather late in the disease. In the remaining three cases the onset of attacks began before other neurological evidences of tumor. One of these remained subjectively and objectively free except for the late development of signs of increased intracranial pressure.

The lesions in the majority of patients were so situated as to either compress or displace the sylvian vessels. Thus three were located in the temporal lobe and one arose from the sphenoidal ridge. One of these patients, with the lesion on the left, had a transitory aphasia following the attacks. The remaining three had tumors in the frontal and frontoparietal lobes and suprasellar region.

Jacksonian Epilepsy.—There were sixty-five patients with Jacksonian epilepsy. These cases were divided into three major groups according to the predominating type of attack. The first group includes thirty-six cases with pure motor attacks, the second, twenty-three with sensori-motor attacks, and the third, six with pure sensory attacks.

Among the patients with motor Jacksonian attacks only one had generalized convulsions and none had sensory Jacksonian spells. On the other hand, several of the patients with sensory-motor attacks had attacks of pure motor Jacksonian epilepsy from time to time, and one of them had generalized convulsions.

According to Hughlings Jackson the severity of the attack depends on the

degree of discharge. This agrees with our findings in regard to loss of consciousness and also the sequence of symptoms during the attack. The majority of patients lost consciousness before the attack was completed. In approximately half of these patients the focal symptoms became generalized. When the patient was conscious during the attack the symptoms remained local.

The location of the tumors responsible for Jacksonian epilepsy is given in Chart III.

It may be seen that tumors of the parietal lobe and paracentral lobule produce focal attacks exclusively. In these two regions, there were forty-one tumors which caused focal convulsions. With the frontoparietal growths, the seizures were predominantly Jacksonian in character. The lesions of the olfactory groove and sylvian fissure, with but one exception, when associated with convulsions caused focal seizures.

A study of the type of Jacksonian seizure and the location of the tumor as seen in Chart IV revealed several interesting facts.

The first is that frontoparietal and paracentral lesions caused either a pure motor or pure sensory type of fit. Another interesting point is that parietal lobe tumors caused either a motor or sensori-motor seizure with the exception of one case which had pure sensory attacks. The frontal lobe tumors caused chiefly a motor type of fit which is more in keeping with lesions in this location when the tumor is large.

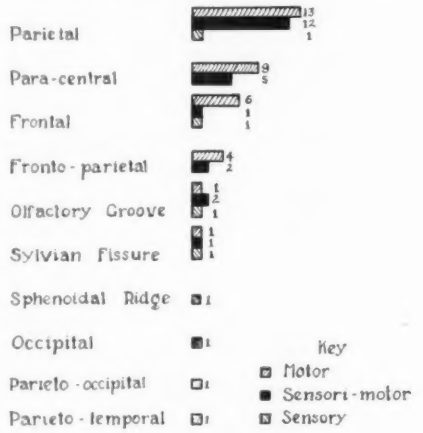

CHART IV.—The locations of the tumors with the type of focal seizure they produced.

On the whole, the frequency of attacks is higher in the Jacksonian group of patients than those suffering from general convulsions. Forty-one of the sixty-five patients gave a history of more than twenty-five attacks, the majority having many more than this figure. The remaining twenty-four patients had less than twenty-five attacks.

Analysis of the progression of symptoms in these cases reveals that the majority had Jacksonian epilepsy before other evidences of tumor. There were forty-three patients with focal attacks as the first sign or symptom. Nine of these had no other evidences of brain disease. Of the remaining twenty-three patients, ten developed a hæmiplegia, hæmiparesis, or as in one case, a monoplegia following the onset of the attacks. These neurological signs manifested themselves directly after an attack in practically all of the ten patients.

In looking over the descriptions of the various types of Jacksonian seizures, several interesting points are brought out. The attacks which were pure motor were all similar in that they were focal and motor in type.

Consciousness was lost in twenty of the thirty-six patients and in half of these the attacks became generalized before completion. In two patients, the entire side of the body was involved simultaneously, instead of the usual initial focus with other parts becoming affected. Although an attempt was made to correlate the location of the tumor with the initial focus of the attack, as shown in Chart V, no definite conclusion could be reached. As one would expect, most of the tumors were located in the frontal, parietal and paracentral region.

The usual description of a sensori-motor attack was a preliminary wave of paræsthesia following which muscular twitchings set in. There were several cases in which the paræsthesias and clonic movements began simultaneously but the motor element never preceded the sensory disturbance.

Initial Focus of Convulsion	Location of tumor
Face	2 Parietal (1 parasagittal) 2 Paracentral 2 Frontal 2 Fronto-parietal 1 Sylvian Fissure
arm	3 Parietal (1 parasagittal) 5 Paracentral (4 parasagittal) 4 Frontal (1 parasagittal) 2 Fronto-parietal (1 parasagittal) 1 Parieto-temporal 1 Sphenoidal Ridge
leg	8 Parietal (6 parasagittal) 2 Paracentral
Entire Side	1 Olfactory Groove

CHART V.—The relationship of the onset of the seizure to the locations of the tumors in the motor type of Jacksonian epilepsy.

Nearly all the tumors responsible for this type of seizure were situated in the frontal, parietal and paracentral regions. Little is to be gained from the study of the mode of onset of the attacks in relationship to the location of the tumor as seen in Chart VI.

The sensory attacks were characterized by either a sensation of numbness or a feeling as though something were crawling beneath the skin in a particular part of the body. This perversion of sensation involved only a small area of the body, lasted but a few minutes and there was little tendency for the paræsthesia to extend beyond the area first disturbed. Only one patient lost consciousness and that was during a single attack. The location of the tumors was so varied that a favorite site for the production of this type of seizure cannot be given.

UNCINATE FITS.—Twelve of the 291 patients had uncinate fits. These were characterized by either gustatory movements, dreamy states, disturbances

of taste or perversion of smell. The attacks were all of one type in any one person. Thus, if the patient had dreamy states the attacks were not complicated by other types of uncinate disturbance. Likewise, the patients with uncinate fits had no associated epilepsy except in one instance. This exception was in a patient who had grand-mal seizures in addition to the uncinate attacks.

Of the twelve patients with uncinate fits, six complained of disturbances of smell. These attacks were described by two patients as burning pumice stone or illuminating gas. Another likened the odor to burning sulphur or metal. Three individuals had crude disturbances of smell which they described as nasty, bad, or ugly. These patients had no other type of seizure.

In all but one of the cases, the tumors were so situated that they either

Initial Focus of convulsion	Location of Tumor
Face	2 Parietal 1 Paracentral 1 Olfactory Groove
arm	6 Parietal (2 parasagittal) 4 Paracentral 1 ,Fronto-parietal 1 Sylvian Fissure
leg	4 Parietal (3 parasagittal) 1 Paracentral 1 Olfactory Groove
Entire side	1 Parietal

CHART VI.—The relationship of the onset of the seizure to the locations of the tumors in sensory-motor type of Jacksonian epilepsy.

directly or indirectly compressed the uncinate gyrus. Two of these lesions arose from the sphenoidal ridge, one from the olfactory groove and one in the temporal lobe. The one exception was an occipital lobe tumor.

Attacks in which taste was disturbed were present in three cases. One patient's seizures were characterized by a very sharp metallic taste. The fit was complicated by visual hallucinations of form and color. In this case, the lesion was in the frontal lobe. The second patient, with a temporal lobe lesion, had attacks which were characterized by chewing movements and salivation during which there was mental confusion. The third patient, with a lesion arising from the sphenoidal ridge, had gustatory attacks, the nature of which could not be determined.

The remaining three patients with uncinate fits had attacks characterized by a dreamy state or sense of unreality. Unfortunately, the descriptions of the attacks are not complete. In one of the patients consciousness was lost during several of the seizures. These spells were caused by tumors of the olfactory groove, parietal and temporal lobes.

Thus in ten of the twelve cases, the growth was so situated that pressure was made directly or indirectly upon the uncinate region. The other two cases with parietal and occipital lobe tumors were probably due to distortion of the structures at the base of the brain with irritation of the uncinate gyrus.

Post-Operative Convulsions.—The ninety cases with epilepsy were studied for the incidence and character of the epileptic seizure following operation. It was found that twenty-four died too soon to warrant discussion. Of the remaining sixty-six patients, twenty-four were completely relieved of the seizures. Of these twenty-four, three were relieved by the use of luminal after having several attacks following operation. Three others had attacks for a period of one to one and one-half years after operation, at which time they ceased, never to recur. The average follow-up period of these cases was four years.

The remaining forty-two patients continued with seizures as before operation. Four of these had a recurrence of the growth so that the primary cause was not removed. The others as far as could be determined did not have recurrence. The condition of the underlying brain was not stated in all the operative notes but in those cases in which a definite statement was made, a surprisingly large number did not have a contused or lacerated cortex.

The nature of the attacks in most instances was approximately the same as the pre-operative seizures. In four cases the spells, having been previously associated with loss of consciousness, were of a minor degree.

Taking each group separately, we find that of the eighteen patients with generalized convulsions, eight had an early death, five were completely relieved and five continued to have attacks. Of those that continued to have attacks, one had only one spell and two others had mild seizures. In another case, the attacks were absent for several years after operation and then recurred. As far as could be determined, there was no return of the tumor.

In the petit-mal group of seven cases, four died early, one was completely relieved of the attacks, and two continued to have this type of seizure, one of whom had very mild attacks.

The Jacksonian group of sixty-five cases was less favorably affected. Twelve were excluded because of early death, sixteen were free from attacks, and thirty-seven continued an uninterrupted course of focal seizures. In this group, the six patients with sensory type of attacks were most beneficially influenced. Only three continued to have spells following removal of the growth, and two of these had attacks of a very mild character. Of the thirty-six patients with a motor type of fit, five were completely relieved and thirty-one continued to have spells. Three of the latter, after a period of six months to two years, were relieved of the attacks. One of the patients with continuance of spells had a recurrence of the tumor. Of the fourteen patients with a sensori-motor type of convulsion, three had an early death, eight were completely relieved and thirteen continued as before operation.

Four of those unrelieved, however, were subsequently helped by luminal and had a cessation of attacks after two years.

Turning now to the 201 cases in which there were no convulsive seizures before operation, it was found that thirteen developed convulsions following operation. Eight of these had Jacksonian epilepsy with loss of consciousness. The remaining five had seizures of the grand-mal type. In five of the thirteen cases there was a recurrence of the tumor. The location of the tumors in this group was as follows: five in the frontal lobe, four in the parietal lobe, two from the sphenoidal ridge, one in the occipital lobe and one from the olfactory groove.

The twelve with uncinate fits were relieved in seven instances. Two were early deaths and three continued to have the attacks. One of the patients with post-operative attacks had a suprasellar lesion too large for complete removal, and the attacks became grand mal. The location of the tumor in the other two patients with continued attacks was temporal lobe and olfactory groove.

SUMMARY

The incidence of epilepsy in this series of 291 cases of meningioma was 30.9 per cent. or ninety cases. In these ninety cases, there were eighteen of grand mal, seven of petit mal, and sixty-five of Jacksonian seizures. This latter group was divided into thirty-six cases of a motor type of attack, twenty-two of a sensory-motor spell and seven of a pure sensory seizure. Aside from these ninety cases, there were twelve of uncinate fits.

In fourteen of the eighteen cases of generalized convulsions the lesions were in the frontal lobe, temporal lobe or arising from the sphenoidal ridge. Fifty-four of the sixty-five cases of Jacksonian epilepsy had tumors involving the frontal and parietal lobes. Ten of the twelve cases of uncinate fits had tumors in close relationship to the uncinate gyrus.

The incidence of epileptic seizure was greatest in tumors of the frontal, parietal and temporal lobe. There were 116 patients with tumors in this region, and eighty had convulsions. All except sixteen of these had focal attacks. In the twenty-one cases of tumor located in the posterior fossa, not one was complicated by convulsive seizures.

Sixty-six patients had pre-operative convulsions. Twenty-four were relieved after removal of the tumor in an average follow-up period of four years. Thirteen patients of the 201 cases without convulsions developed seizures after operation. Eight of these had Jacksonian seizures, while the remaining five had grand-mal attacks.

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THE OCCURRENCE OF FRANK HEMIANOPSIA

PERIMETRIC STUDIES OF 2,500 CASES

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Seven years ago there was established at the University Hospital a department devoted solely to perimetry, where certain research problems might be undertaken as well as perimetric studies on routine cases of certain types. This department did not exclude perimetric studies being made in the out-patient department for patients reporting for ocular treatment or for those of certain types reporting for correlating studies from other departments of the hospital.

Since this department was established 4,345 fields have been charted relating to 2,525 patients. All of these fields have been made by one examiner (Wentworth) and under identical conditions as this relates to methods, instruments, illumination, stimuli and surrounding field. With this material we have undertaken a preliminary study of hemianopsia but in doing so we have only selected those fields that would be considered as frank instances of hemianopsia by the most skeptical critic. For certain reasons we eliminated the quadrantanopsias, unless this condition existed in one eye and was associated with a hemianopsia in the other. These fields will be analyzed at a subsequent time. On this account the number of instances of hemianopsia has been materially reduced as would be appreciated especially by those familiar with the many complicated and border line fields encountered in the study of neurological cases, which comprise the bulk of the material under discussion.

The selections and groupings have been made solely on the character of the fields, without reference to the lesion. Further, the associated signs and symptoms have not been referred to or consulted and in this way many "slants" or slight cuts have been eliminated which if considered in conjunction with other signs doubtless would be regarded, and quite properly, as hemianopsic, and which in certain cases might prove to be the determining factor in diagnosis or localization. So too, we have excluded certain intraocular lesions that at times may produce fields simulating the hemianopsia found in certain intracranial lesions. This relates chiefly to glaucoma, certain types of optic atrophy, vascular lesions, and occasionally, certain exudative lesions of the choroid and retina.

For those not accustomed to the classification of perimetric fields it would be difficult to appreciate the difficulties encountered in attempting to isolate the various groups. In this classification we have typed the cases according

to the form fields charted by the 1° and 2° white stimulus on the Feree-Rand perimeter, unless otherwise stated. Since we believe in the diagnostic value

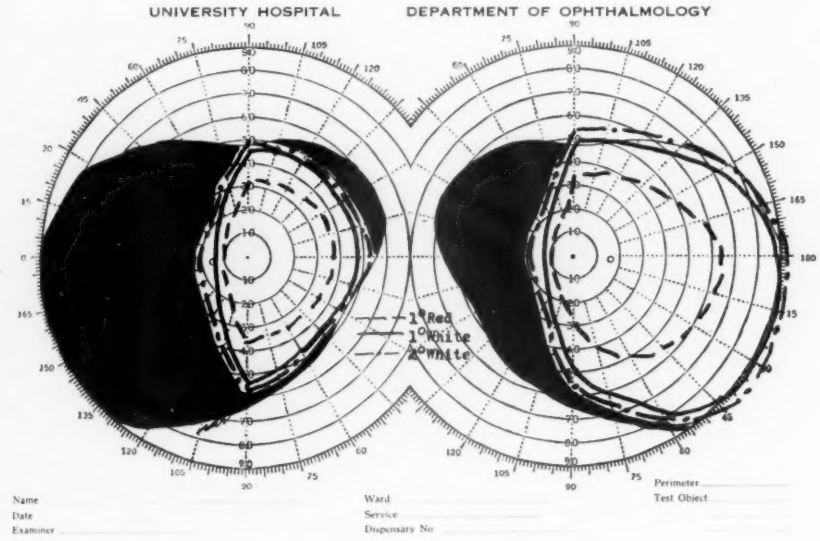

FIG. 1.—Left homonymous hemianopsia, overshot field.

of certain colored stimuli, especially red in routine work, it has been necessary to make a special group showing a hemianopsia for red, where this

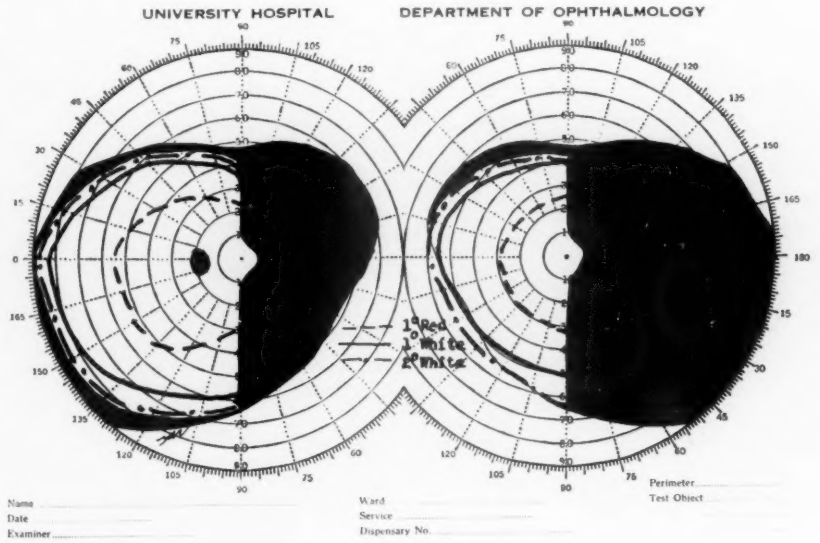

FIG. 2.—Right homonymous hemianopsia, sparing of macula.

stood in sharp contrast to practically full form fields or slight contractions of the form fields that alone would not warrant our placing them in a hemian-

opsic group in accordance with the statements made above. Needless to say many of these patients were subjected to operative procedures, but in this study we have included only pre-operative fields.

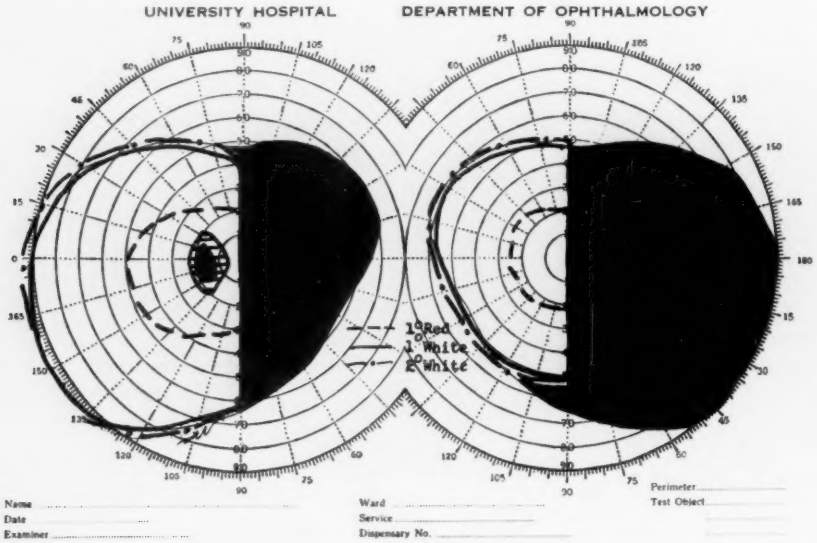

FIG. 3.—Right homonymous hemianopsia, dividing line through fixation.

Temporal Hemianopsia.—In this group we find listed seventy-five cases distributed as follows: Twenty-three had a complete bitemporal hemianopsia

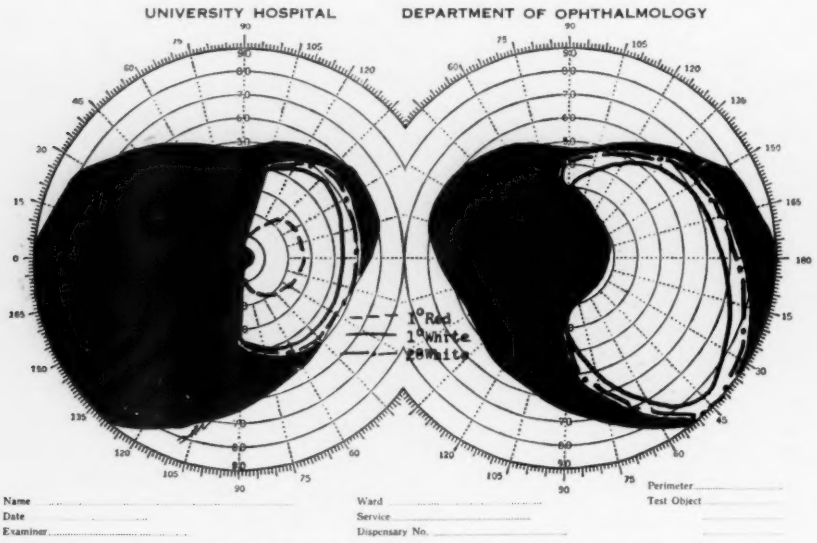

FIG. 4.—Left homonymous hemianopsia, loss of central field.

and twenty-four cases, while bitemporal, were incomplete. Twenty-eight cases manifested a unilateral temporal hemianopsia of which twenty-two were complete and six incomplete. Needless to say in many of the unilateral

cases, if we were to judge from the fields alone it would be impossible to say whether the original field changes had been bitemporal or a right or left homonymous hemianopsia.

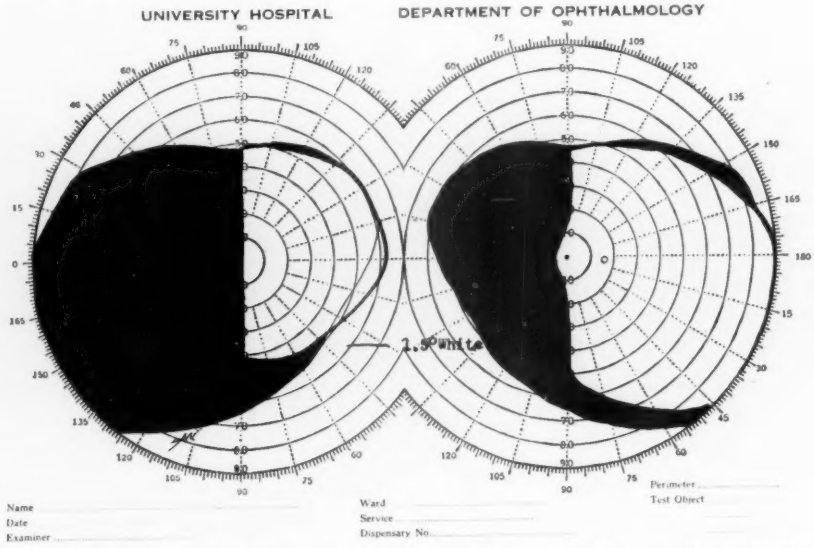

FIG. 5.—Left homonymous hemianopsia, mixed type. Macula spared right eye; through fixation in the left.

Complete Bitemporal Hemianopsia.—The twenty-three cases in this group we classified as follows: Overshot, seven; macula spared, five; through fix-

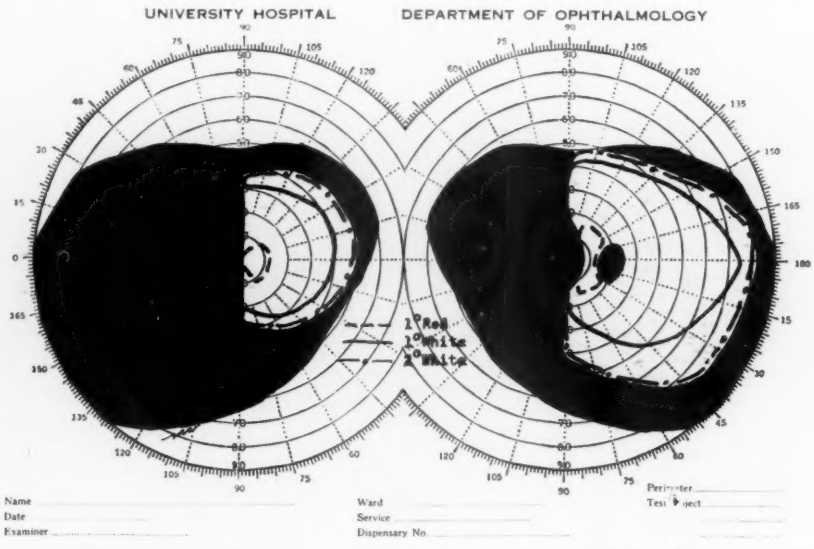

FIG. 6.—Left homonymous hemianopsia, mixed type. Loss of central field right eye; through fixation in the left.

ation, four; loss of central field, one; mixed, six. The mixed group was made up of those fields where one of the above conditions existed in one eye and another in the other eye, such as, an overshot field in the right eye

and through fixation in the left eye. In the incomplete group we included those instances where there was a loss of half the field.

Unilateral Temporal Hemianopsia.—The twenty-two fields classified as

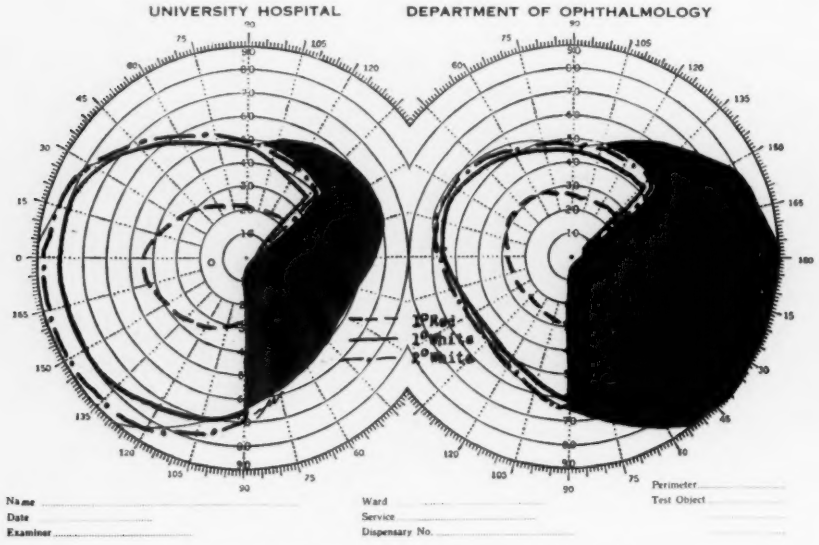

FIG. 7.—Incomplete right homonymous hemianopsia.

complete, permitted of the following subdivisions: Overshot, two; macula spared, the other eye blind, five; macula spared, the other eye not blind, two; through fixation, the other eye blind, five; through fixation, the other eye

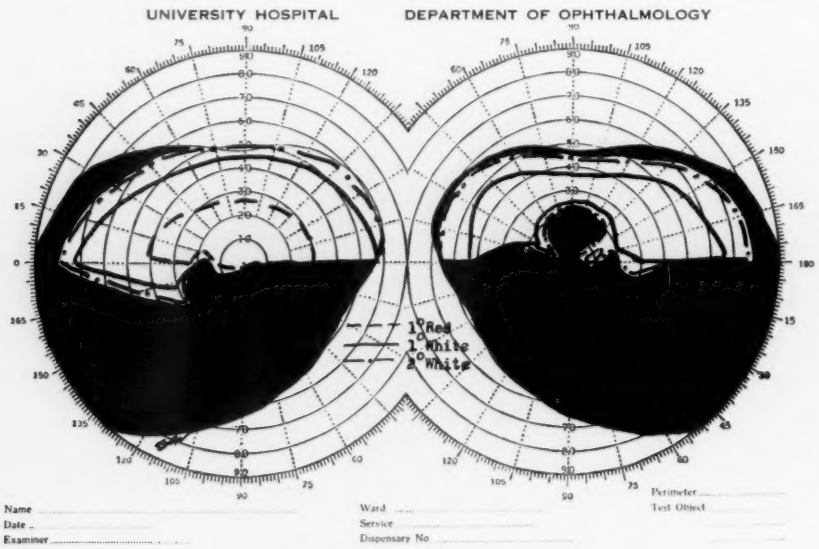

FIG. 8.—Altitudinal hemianopsia, inferior type.

not blind, none; loss of central field, two; mixed, the other eye blind, five; mixed, the other eye not blind, one. The "mixed" here refers to variations in the fields for 1° and 2° white and 1° red.

The incomplete unilateral cases admitted of the following assignments: Incomplete, the other eye blind, four; incomplete, the other eye not blind, one; incomplete, loss of central field, one.

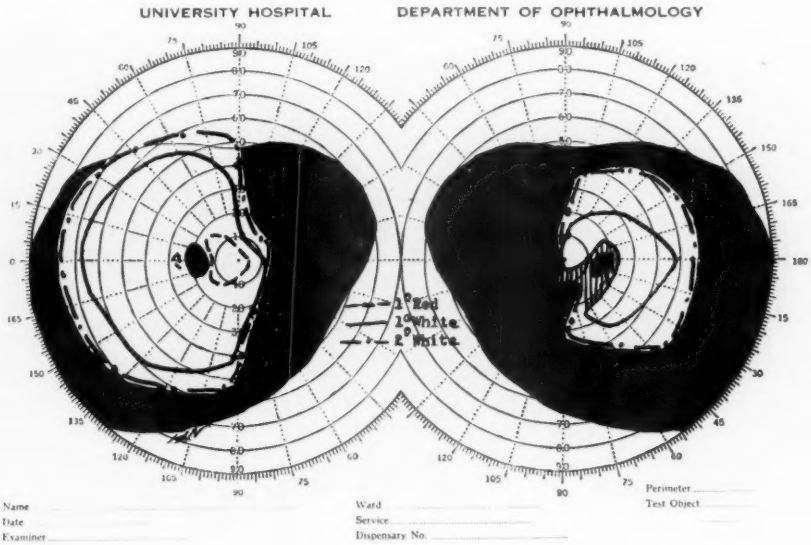

FIG. 9.—Binasal hemianopsia.

Right Homonymous Hemianopsia.—In this group of fifty-six cases, forty-one were complete and fifteen incomplete.

Complete right homonymous hemianopsia. These were divided as fol-

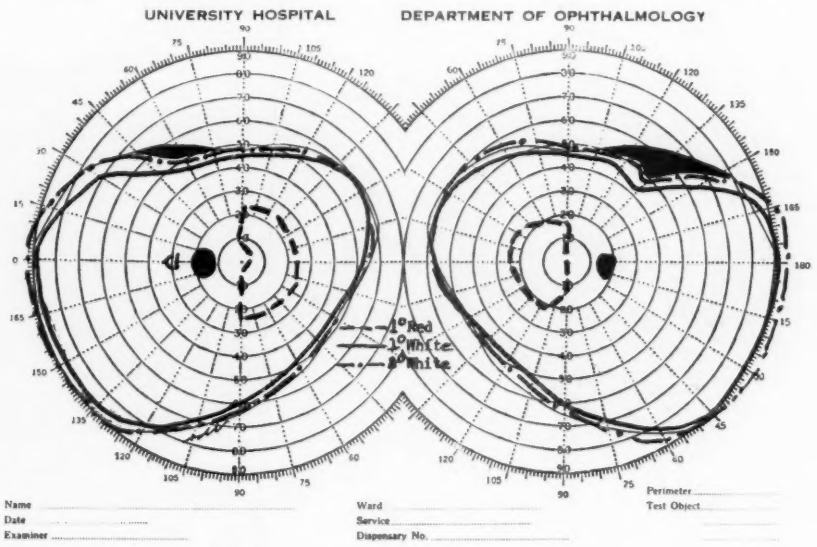

FIG. 10.—Bitemporal hemianopsia for 1° red.

lows: Overshot, eleven; macula spared, nineteen; through fixation, eight; loss of central field, none; mixed, three.

Left Homonymous Hemianopsia.—Here, in marked contrast to the right

homonymous group, there were ninety-four cases, fifty-one complete and forty-three incomplete.

Complete left homonymous hemianopsia. The following classification is

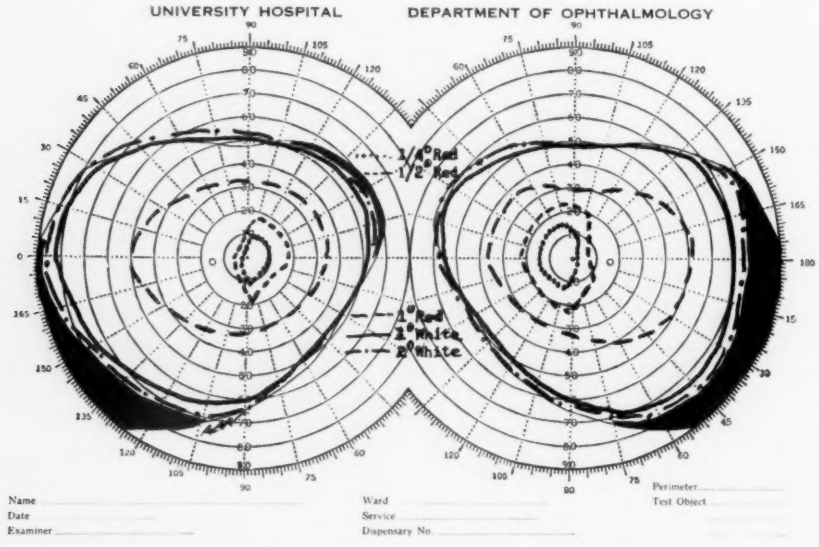

FIG. 11.—Bitemporal hemianopsia for ½° and ¼° red.

applicable to this group: Overshot, fourteen; macula spared, six; through fixation, sixteen; loss of central field, four; mixed, eleven.

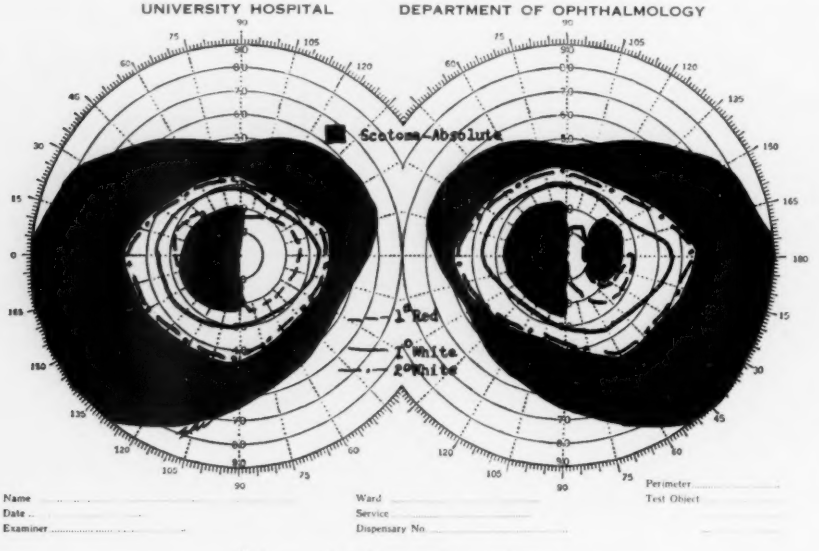

FIG. 12.—Left homonymous scotomas.

Altitudinal Hemianopsia.—In this group, comprising both the superior and the inferior types, there were eleven instances of a bilateral hemianopsia and five of a unilateral manifestation.

Nasal Hemianopsia.—As is well known binasal hemianopsia is not fre-

quently encountered as the result of intracranial disease. Among our cases we have so classified seven fields, while in nine instances a nasal hemianopsia was found as a unilateral manifestation. In certain of the latter type the other eye was blind and the remaining nasal field, doubtless, tended to a terminal result of a right or left homonymous hemianopsia.

These unilateral cases were grouped as follows: Overshot, five; macula spared, two; through fixation, one; loss of central field, one.

Hemianopsia for Color.—Here red was the only color used, always with a 1° test object and in certain instances with a ½° and ¼°. The manifestations were chiefly of the bitemporal type as will be noted in the following grouping: Bitemporal, twenty-three; unilateral temporal, six; right homonymous, four; left homonymous, one.

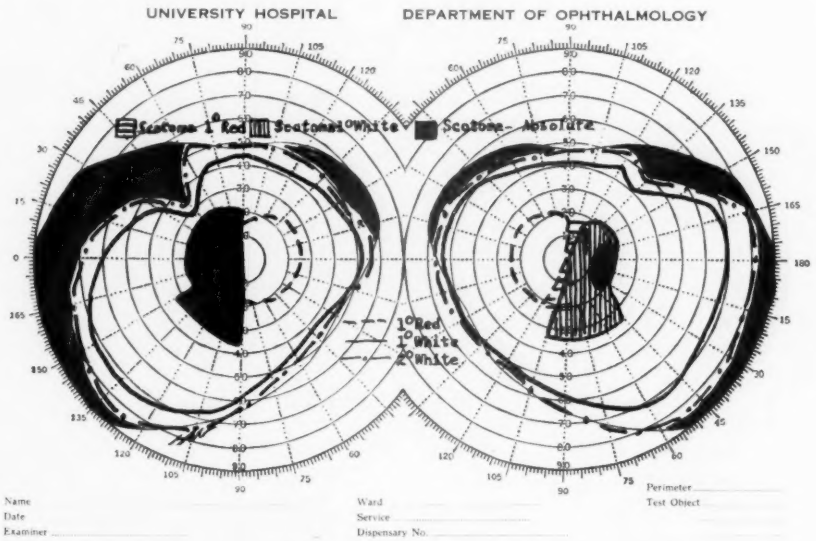

FIG. 13.—Bitemporal scotomas.

Hemianopsic Scotomas.—In certain fields hemianopsic scotomas were the outstanding features and we found sixteen fields showing such defects, but in three instances they were associated with other field changes and were classified in other groups. In these three cases, the scotomas were bitemporal. Among the remaining thirteen cases, eight were bitemporal and three were of the left homonymous type, while in two instances there was a large temporal scotoma associated with blindness in the other eye.

From the above it will be noted that as a result of our studies we found 291 instances of frank hemianopsia, and if we include the scotomas, 304 hemianopsic defects among the fields of the 2,525 patients examined. As was mentioned above no typical quadrantanopsias were included. We have also excluded two fields, one a right and the other a left homonymous hemianopsia where the changes were definitely tubular, in our experience an unusual manifestation even in hospitals where many functional cases are seen. One of these patients was an epileptic, the other, a brain tumor suspect.

THE FUNCTIONS AND STRUCTURE OF THE NEURAXIS IN REGARD TO VOLUNTARY AND REFLEX MOVEMENTS

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The object of this communication is to call attention to the intermediary mechanism between the upper and lower motor neurons of the neuraxis and to emphasize certain correlations which seem of importance for an understanding of some well-known phenomena which are not explained on the basis of direct connection between the central and peripheral motor tracts.

The work of Sherrington[3] on reflex spinal-cord mechanisms and of Magnus and his co-workers on decerebrate rigidity have made it evident that the brain stem and spinal cord are endowed with elaborate pattern mechanisms. These mechanisms of the neuraxis consist of neuron systems which do not belong either to the projection fibres from the brain or to the peripheral motor neuron (the final common motor pathway). In brief, there is an elaborate and important system of motor neurons in the neuraxis entirely distinct from the upper and lower systems of motor neurons.

How does this mechanism participate or how is it utilized to the execution of normal voluntary and reflex movements? The conception is presented that in the execution of normal voluntary and reflex movements this mechanism is activated by tracts from higher levels: the pyramidal, cerebello-rubrospinal, tectospinal, Deitero-spinal, reticulospinal tracts, and by the afferent peripheral nerves. The system under discussion is a distributing mechanism which activates the final motor pathway throughout the length of the neuraxis by appropriately timed and coördinated stimulation and inhibition of selected peripheral motor unit neurons.

Let us consider the operation of the respiratory centre in respect to such a conception. After decerebration above the medulla in the higher animals respiration proceeds automatically. Coördinated series of reciprocal movements sufficient to maintain an equilibrium of gaseous exchange continue and maintain respiratory metabolism. The activity of the respiratory centre is subject to modifications by variations in the constituents of the blood and also by peripheral stimuli from different parts of the body.

There is evidence to indicate that the neurons of the respiratory centre as a group have a certain inherent automaticity independent of influence through either the circulation or peripheral stimuli. Adrian[11] describes experiments on the isolated medulla of the goldfish in which action currents were shown having a rhythm closely approximating normal gill action.

The condition of respiration in decerebrate animals is closely approximated in man in certain cases of pseudobulbar palsy in which there is an interruption of supranuclear motor pathways on both sides. In this condition respiration proceeds automatically, but voluntary control of the move-

ments is almost entirely lost. Voluntary coughing, holding the breath, or blowing out a candle is impossible. Cheyne-Stokes respiration is common, and during the hyperpnœic stage the pattern of movements has a relatively wide spread.

The respiratory centre situated in the reticular formation ventral to the calamus scriptorius of the medulla has long been recognized. It is symmetrically bilateral but may continue to function as a whole after being divided longitudinally in the mid-line (Howell[1]). Destruction of one side only affects the respiration of the same side of the body (Howell and Erb[2]). Under varying circumstances respiration varies according to the degree of stimulation, and as its activity increases, more and more of the accessory muscles of respiration are brought into play. In the normal state this spread of activity of respiratory movements extends to include almost the entire musculature of the body in a single pattern of movements.

To explain commonly observed respiratory phenomena in decerebrate animals and in the clinical picture of pseudobulbar palsy in man it is necessary to conceive of the respiratory centre as having ramifications throughout the entire extent of the neuraxis and connecting with peripheral motor nuclei at all levels. An important feature of this mechanism is its adaptability to the needs of respiration; or otherwise stated, its capacity of varying response to varying stimuli.

Another example of a coördinating mechanism of the brain stem is that controlling the extra-ocular movements. This mechanism is less well understood than that of the respiratory centre since all normal eye movements are either reflex or voluntary and no automatic movements are involved. By animal experiments definitely coördinated reflex movements of the eyes may be demonstrated after decerebration above the ocular nuclei. In man, clinical cases frequently occur in which disturbances of conjugate movements exist in the absence of paralysis of any of the extra-ocular muscles *per se*. Medical literature records innumerable cases of Parinaud's syndrome, skew deviation, paralysis of vertical and lateral movements, and paralysis of convergence in which all of the extra-ocular muscles function in certain movements. These clinical phenomena cannot be explained on the basis of interruption in the pathways of the cerebral projection fibres because lesions of the projection tracts above the ocular nuclei do not give this picture. Lesions of the peripheral motor neurons to the extra-ocular muscles result in paralysis of muscles. The loss of associated eye movements without muscle paralysis must therefore be postulated on lesions of a coördinating, distributing, motor mechanism in the vicinity of the ocular nuclei (Parinaud's conception).

Sherrington's work with decerebrate animals and the work of many others who have followed in the same field have demonstrated numerous motor patterns in which muscles are activated or inhibited, and function in coöperation or in reciprocal relation to each other, and in sequence employing different groups of muscles to effect a series of coördinated movements.

The scratch reflex, reflex standing and walking, and the Magnus and de Kleijn phenomena are familiar examples of such patterns. Recalling the fact that the peripheral motor neuron is only the final common pathway, and takes part in the neural pattern only in transmitting to the muscles the impulses it receives, all of the activities, all the stimulations and inhibitions, groupings of impulses, and sequences of action in decerebrate animals must be under the control of a neuron system in the neuraxis distinct from and relatively independent of the projection tracts from the brain.

The well-known fact that cortical stimulation results only in action of muscle groups and not of individual muscles indicates that patterns of motor distribution must exist at some level. To what extent these patterns are located in the cortex or cerebral structures on the one hand and to what extent the patterns of the neuraxis are employed on the other is not entirely clear. But it is evident that the lower patterns are of great importance in normal motor functions. Practically all of the coördinated motor activities of decerebrate animals are essentially cross-sections of normal, well-established and habitual voluntary movements.

In the analysis of normal voluntary movements it is useful to divide them into (1) movements which are strictly unilateral, and (2) movements which are accomplished by bilateral muscle groups either symmetrical or not. Unilateral movements are executed by some of the muscles of facial expression and by the muscles of the extremities. All other movements are bilateral and these include all movements of the head, eyes, muscles of mastication, deglutition, vocalization, and all trunk movements. Both phylogenetically and ontogenetically the bilateral movements are more primitive than the unilateral. It is an interesting and well-recognized fact that the clinical picture of hemiplegia consists predominantly and almost exclusively of the loss of function of unilateral movements.

As an explanation of the distribution of paralysis in hemiplegia it has commonly been assumed that projection fibres from the motor areas of both sides of the brain are distributed to anterior horn neurons supplying the muscles not involved in hemiplegia. This explanation is not convincing and has not been supported by anatomical facts. In an absence of an adequate knowledge of anatomy it may be permissible to suggest another working hypothesis. In this sense a conception has been formed that innumerable patterns for bilateral movements exist in the neuraxis which can be activated by fibres from the corticospinal areas from either hemisphere. Such neuron groups bilaterally situated and commissurally connected, and functioning as coördinating and distributing mechanisms, would be conveniently located to be activated by fibres from either crossed pyramidal tract and all other projection systems above them, and also by afferent fibres from the periphery in reflex action.

For unilateral movements the neuraxial patterns are unilaterally situated, and in man are activated in voluntary movements mainly by the projection

tracts of one (contralateral) hemisphere. This conception apparently explains the clinical picture of hemiplegia or paralysis of unilateral movements.

Certain muscles participate in both unilateral and bilateral movements; *e.g.*, the pectoral muscles, latissimus dorsi, trapezius and other shoulder muscles function bilaterally as accessory muscles of respiration and unilaterally in voluntary movements of the arm. In this connection it is interesting to analyze certain movements in the hemiplegic patient. In cases of severe cerebral hemiplegia, voluntary arm and shoulder movements are lost and the pectoral muscles cannot be contracted in voluntary unilateral action. But when the patient coughs voluntarily the pectoral muscles on the paralyzed side are brought into action. Unilateral movements of the shoulder are impossible, but by forceful inclination of the head to the paralyzed side (a bilateral movement) the trapezius on the paralyzed side participates. As is also well known, the hemiplegic patient raises the paralyzed arm in reflex yawning, this reflex occurring through the respiratory centre.

In the first stage of severe hemiplegia there is a slight degree of weakness involving bilateral movements on the affected side. This weakness rapidly disappears. Paralysis of associated movements of the head and eyes toward the paralyzed limbs is an example of such weakness of bilateral movements. In analyzing this condition it may be observed that some of the muscles which fail to function are on the paralyzed side and some are on the normal side. For example, the sternocleidomastoid and the internal rectus of the healthy side do not function. The head can be turned normally to the healthy side which action utilizes the function of the sternocleidomastoid and the internal rectus of the eye of the paralyzed side. These phenomena cannot be explained on the basis of known histological facts, but may be explained by the operation of a distributing neuron system in the brain stem.

The concept as outlined is not without anatomical and physiological foundation. The pioneer in this work seems to have been von Monakow,[4] who, in his masterly article on the thalamus, discussed in an appendage to the main subject the anatomy of the intercalated system. In his later text-book the same anatomical plan was enlarged upon and intercalated neurons are stated to be present not only in the spinal cord and brain stem between the upper and lower motor neurons but also in the motor cortex where they function in correlating Betz cells, and in the cerebellum. von Monakow found a warm supporter in Redlich.[5] The basis upon which this concept was postulated was essentially that the pyramidal-tract fibres had been traced by degeneration experiments on young animals to the region between the anterior and posterior horns of the spinal cord. Both authors had failed to trace the fibres to the anterior horn cells, but had traced them to the substantia reticularis.

Hoff[6] studied the same problem in the cat and monkey and found that some of the pyramidal-tract fibres actually terminated around the anterior horn cells but that many also ended about the cells of the posterior horns. His eight sections show far more ending, as von Monakow and Redlich had

found them, than in the anterior horn cells. Hoff's method was entirely different from that of the other investigators as he used his newly discovered bouton termination method.

Martin,[7] working with human material from cases of hemiplegia, traced the pyramidal-tract fibres to the gray matter in the angle between the anterior and posterior horns. Winkler and Kappers, according to Spiller,[8] believed that an intercalated neuron existed between the corticospinal tract and the motor cranial nerve nuclei.

Brouwer[9] has shown the same termination of the corticospinal fibres in the rabbit. Incidentally, however, he believed that the Deitero-spinal tract ended in the anterior horn cells. He emphasized the fact that the ground bundles of the spinal cord consisted of fibres ending around the anterior horn cells.

Sherrington has shown that diffuse coördinating mechanisms in the spinal cord operate entirely independently of the brain. Herrick[10] believed that "It is probable that in most, if not in all cases, a short neuron is intercalated between the upper and lower motor neuron in the spinal cord." Further, "It must be borne in mind that the higher correlation centres which serve individually variable behavior in higher vertebrates can act only through the agency of the lower reflex centres."

The respiratory centre has been located in the formatio reticularis of the medulla, and there is much evidence to indicate that many of the fibres of the pyramidal tract terminate in the cells of the reticular formation of the spinal cord. It may be of significance that the formatio reticularis throughout the brain stem is in close relation to the motor nuclei. The hypothesis is suggested that the reticular formation of the brain stem and spinal cord, the posterior longitudinal bundle, the reticulospinal tract, and the ground bundles of the spinal cord form the main anatomical structure of the important motor neuron system under discussion.

Nielsen suggested in a personal communication, that the well-known choreic and athetoid movements seen in syringomyelia may be the result of irritation of the intercalated system of neurons in the cervical cord. This seems reasonable in view of the fact that the central cavity extends laterally where its degenerating walls would irritate the cells of the substantia reticularis before the process destroys the anterior horn cells upon which intercalated cells exert their function.

SUMMARY

On a basis of anatomy, physiology, pathology, and clinical observations, an hypothesis is presented to explain facts concerning the motor mechanism which are not comprehensible on the basis of only an upper and a lower motor neuron. In brief the hypothesis suggested is that the main connection of the upper motor neuron is not direct with the lower motor neuron but through an intercalated system of neurons which acts as a correlating and distributing mechanism for voluntary and reflex motor impulses. This mechanism forms

a system of patterns throughout the brain stem and spinal cord. Anatomically, the system consists of fibre tracts such as the posterior longitudinal bundle and reticulospinal tract. The substantia reticularis of the brain stem and spinal cord and the ground bundles of the spinal cord probably constitute part of this system.

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BRAIN ABSCESS

EXTERNAL RUPTURE OF "CAPSULE" WITH PERICAPSULAR BRAIN NECROSIS

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In 1924 I[1] described an operative procedure for the treatment of brain abscess in which the important features were the exposure of the abscess "capsule" through a large-sized opening in the skull, dura, and cortex, in order to allow the abscess cavity to herniate through this defect; followed by dakinization of the herniating brain substance until it subsided within the skull. Subsequent epithelialization of the granulating surface was then accomplished. This procedure was suggested because I believed that the entire abscess area should be removed leaving no infective residuum within the skull, thus preventing the formation of a secondary abscess. The operative technic with additional refinements in post-operative care was further described in two papers published in 1924[2] and 1925.[3]

Later experience with this operation showed that in some instances, when the abscess cavity was evacuated, there was a tendency of the "capsule" to collapse almost immediately. For this reason I suggested (1929) the use of pliable baskets made of fine mesh silver wire in order to "conduct" the abscess cavity to the point of complete herniation and at the same time allow of adequate dakinization of the interior of the abscess cavity. The first case was successfully managed in this manner in 1931.

In April, 1932, I was confronted with a patient in whom the abscess cavity had spontaneously evacuated most of its contents through a mastoid wound, leaving the "capsule" collapsed, surrounded by an area, approximately one-half inch thick, of necrotic brain tissue. The various technical procedures described by Mosher and Cahill, Grant, Coleman, Adson, Dandy and Eagleton were thought to be impracticable in this case. It was most difficult, if not impossible, to locate the capsule and insert any type of drainage material. Furthermore, even if it had been possible to insert a type of drain into the capsule, such drain would not have adequately dealt with the pericapsular necrotic area. Therefore, an elaboration of my original operative procedure was found necessary, and was carried out. A detailed description of the method used this time is given in the following report.

Case Report.—Clinical Record No. 224483. Manhattan Ear, Nose and Throat Hospital. Case referred by Dr. Foster Kennedy. Patient, white, female, age 45 years. *History* (from notes by Dr. E. Ross Faulkner and Dr. S. Bernard Wortis). The patient had a nasal infection during the last week in March, 1932. On April 1 she began having severe pain in her left ear. Examination one and one-half hours after the onset showed a marked bulging of the drum and slight swelling of the canal walls. A myringotomy was done, but the pain continued. On April 2 there was a marked periostitis

of the canal wall above and posteriorly. On April 3 the patient continued to have a severe headache and some vomiting which persisted throughout the next day. On the morning of April 5 there was definite rigidity of the neck. Her temperature rose to 100.4°, and she complained of stiffness of the neck. This neck rigidity became pronounced and she was seen by Dr. Foster Kennedy who found that she had a diminution of the right abdominal reflex, a positive Kernig sign, and the diagnosis of meningitis was made. That morning a lumbar puncture was done by Dr. S. Bernard Wortis. The cerebrospinal fluid was cloudy and showed marked pleocytosis and absent sugar. Antimeningococcic serum was given. The spinal fluid cultures were reported negative, although one laboratory, (Dr. Phoebe DuBois) reported finding one or two chain streptococci in the smear. Cultures continued to be negative. On April 6 another lumbar puncture was done with injection of more serum. This was repeated on April 7. On April 8 there was a sudden drop in temperature from 105° to 96°, and the patient began to improve. On April 9 a rather severe attack of facial erysipelas developed and lasted for a week. During this time there was a free discharge from the nasal sinuses and intermittent discharge from the left ear. Cultures from the ear and nose showed streptococcus hæmolyticus. Radiographical examination showed no mastoid involvement. The meningeal symptoms continued to clear and it was not deemed advisable to continue intrathecal injections of antimeningococcic serum due to the fact that no specific meningococci were found, and because the patient continued to improve. On April 10 the patient continued to have severe headaches which at times required morphine. She had only occasional vomiting.

Neurological examination.—By Drs. Foster Kennedy and S. Bernard Wortis April 17 to 20 showed the following: "Cranial nerves normal except for some slight fullness of the veins of both fundi. Grossly there was no field defect. Slight aphasia in the nature of an anomia was present. The patient had much difficulty in naming objects and would describe things by circumlocution. There was no auditory aphasia. There was very slight flattening of the right lower face and diminution of the right abdominal reflex. The other cranial nerves were normal. No motor weakness of the extremities was noted. Coördination tests were normal, and deep reflexes were entirely normal. There was definite plantar flexion on the left side with only an equivocal plantar response on the right. Sensory status entirely normal. There was no astereognosis. At one examination there was a suspicious slight upper quadrantic visual field impairment by gross testing."

The patient continued to improve, but she had persistent headache. The temperature fell somewhat, but never reached normal. The aphasic defect continued to be present, and after ten days of this behavior another lumbar puncture was done. The pressure was normal and only two or three cubic centimetres of cerebrospinal fluid were removed. This fluid was clear and showed a cell count of approximately seventy lymphocytes. The sugar content was normal. The meningeal signs had cleared, but she continued to complain of some pain behind the left ear. On two occasions recently there was quite a profuse discharge from the left ear.

On April 20 there was a rise in temperature and it was deemed advisable to have a radiographical examination of the left mastoid made, in view of the fact that the cerebrospinal fluid was clear, that her sinuses were negative, and that the attack of erysipelas had resolved. Radiographical films showed what apparently was a slight softening in the region of the mastoid antrum. The diagnosis of a probable subdural abscess with a possible brain abscess was made.

On April 20 a mastoidectomy was performed by Doctor Faulkner. There was very little pathology found in the mastoid process itself. The bone was very hard and eburnated. Only three small cells were found. These did not contain pus. Exposure of the lateral sinus showed it to be normal. However, in the roof of the aditus, ne-

crotic bone was found and when this was removed, exposing an area of dura about one inch in diameter, and the dura was elevated, there was an escape of a considerable amount of thick, yellow pus which on culture proved to contain streptococcus hæmolyticus. When the dura was allowed to fall back in place against the bone, the discharge of pus ceased, but when the dura was again elevated, there was another gush of pus. On repetition of this elevating and lowering of the dura four or five drachms were removed, and then the dura, which had been quite tense and non-pulsating, began to pulsate. Because of this pus-pocket finding and the history of anomia, we felt that we were dealing with a temporosphenoidal abscess which had perforated through the basilar dura, and now had been partially drained. (Fig. 1.) Nothing further was done at the time except inserting a small rubber dam drain beneath the dura, and packing the mastoid wound with iodoform gauze. The wound was left wide open. The patient's condition was fair throughout the next three days when she again became critically ill. Her temperature ranged between normal and 100.4° with respirations of 20 and pulse 72 to 94.

FIG. 1.—Transverse section showing contracted capsule after partial evacuation at the time of the mastoidectomy. The mastoid process has been, for the most part, removed. The cavity shows dark. The site of the spontaneous perforation of the abscess through the basilar dura is shown just above the remaining portion of bone in the upper limit of the mastoidectomy wound. The area about the contracted capsule consisted of broken-down necrotic brain tissue.

The reports of the differential blood examinations were as follows: (April 22, 1932) Red blood-cells 4,260,000; white blood-cells 27,300. Polymorphonuclear neutrophiles 90 per cent.; small lymphocytes 8 per cent.; large mononuclear 2 per cent.; hæmoglobin 77 per cent.; color index 0.9. (April 23, 1932) Red blood-cells 4,230,000; white blood-cells 22,100. Polymorphonuclears 89 per cent. (7 per cent. immature); small lymphocytes 7 per cent.; large mononuclear 7 per cent.; hæmoglobin 78 per cent. (April 24, 1932) Red blood-cells 4,200,000; white blood-cells 19,600. Polymorphonuclears 80 per cent. (20 per cent. immature); small lymphocytes 14 per cent.; large mononuclear 6 per cent.; hæmoglobin 75 per cent.

Neurological notes by Dr. Foster Kennedy were as follows: "April 23, 1932: General condition improved. Neurological signs same as before. No advance in quadrantic hemianopsia. Fundi as before; no swelling. The patient seems more drowsy than before, brightens easily, but lapses quickly into sleep." "April 24, 1932, 6:00 P.M. Perhaps the veins in the left fundus are more tortuous. Nothing else new noted. Right upper quadrantic hemianopsia same as before. The right plantar reflex has an extensor quality at rest, and on stimulation, is more definitely of Babinski type. Ankle clonus, moderately well sustained, is now present on the right side." "April 25, 1932, 10:30 A.M. Pupils dilated by homatropine. Tortuosity has appeared in the veins of the right fundus, and the disks, both right and left, are redder with tiny injected points. No swelling, but the appearances are those of impending palliœdema. The right upper quadrantic hemianopsia same as before. Right ankle clonus more sustained than yesterday. The right plantar reflex is same as before,

but I find constant change in the left plantar reflex which is no longer definite flexor but is as extensor as the right. Drowsiness is deeper, though pain seems less. Operation will be needed on left temporosphenoidal lobe either tonight or tomorrow morning." On April 25, 1932, it was decided that she should be operated upon for a left temporosphenoidal abscess, and this was done under chloroform anæsthesia administered by Doctor Creevey.

Operative Procedure.—In view of the fact that an open mastoid wound was present, it was necessary, in order to prevent contamination, to make the trephine opening for exploration with the cannula somewhat higher than otherwise would have been the

FIG. 2.—Transverse section showing the removal of the overlying cortex and of the necrotic material about the capsule thus bringing the partially collapsed capsule into view. Further bony removal has been done allowing the basilar dura to sag somewhat downward.

case. Therefore, through a small, vertical incision, placed well above the mastoid wound, the trephine opening was made, and the cannula was inserted downward into the suspected area in the temporosphenoidal lobe (which corresponded to that region of the lobe opposite the exposed area of dura in the mastoid wound). The resistance usually encountered by the capsule of an abscess was not felt, no free pus welled up through the cannula, but by aspiration, thick, yellow pus was obtained. The cannula was then withdrawn. The anterior upper portion of the mastoid incision was then carried farther forward above the ear in a curved direction through the scalp, temporal fascia and muscle, down to the pericranium, and the incision through which the puncture was

made was carried downward to meet the original incision, making it three-limbed. The three scalp and muscle flaps were dissected up from the pericranium, the lower one carrying the external ear, and self-retaining retractors applied. The bony defect was enlarged downward from the trephine opening and upward from the mastoid wound until an area of dura about one and one-half to two inches in diameter was exposed. The dura did not pulsate. A small nick was made in the lowermost portion of the exposed dura and the cannula was again inserted, but this time directly inward, and at a depth of about one and one-half centimetres more thick purulent material was aspirated. The dura was then widely opened by stellate incisions, and the pennant-shaped dural flaps were removed. The circular area of cortex thus exposed measured about one and one-half inches. The cortex itself was firm but injected. Palpation revealed some underlying softening. The cortex was then removed by suction and with the electrosurgical unit; the necrotic area which had been localized by the cannula was exposed and localized and likewise removed, in part, by suction. Here the apex or dome of the collapsed and shrivelled capsule of the abscess then came into view (Fig. 2).

At this point all types of drainage were evaluated and none was considered adequate to deal with this situation. The collapsed capsule could not be properly drained, nor could the remaining portion of the neighboring necrotic brain tissue be simultaneously drained by any formal method. This was a new situation in my experience and called for a new and individual technic. Accordingly the remaining necrotic brain tissue about the capsule was further removed by suction until what was considered fairly well-nourished brain tissue formed the wall of the excavation where the collapsed abscess cavity had been.

The collapsed "capsule" was fixed against the basilar dura, and appeared like a partly filled balloon tied down and floating in the surrounding necrotic brain tissue and purulent material. It measured about an inch in a vertical direction and about three-quarter of an inch in diameter, tapering somewhat toward either pole. The upper half of the capsule was cut away, its wall measured about 2 millimetres in thickness and seemed to be tougher in consistency than the usual distended capsule. It was found to be almost completely empty with exception of some very thick yellow and greenish-yellow inspissated material which was attached to the inner wall, especially at its fixed basilar portion. This remaining portion of the capsule was then removed (Fig. 3) with the exception of a small part which was firmly fixed to the dura. This was touched with carbolic acid followed by alcohol. More of the bone underlying the basilar dura, which was not removed at the time of the mastoidectomy, was then taken away. The area of the brain occupied by the shrivelled collapsed capsule of the abscess and its surrounding necrotic brain tissue, some of which had broken down into thick yellow, and greenish-yellow pus, involved for the most part the temporal portion of the temporosphenoidal lobe, especially that part of the brain underlying the inferior and middle (and possibly extending beneath the superior) convolutions. It did not extend far down into the sphenoidal portion of the lobe. The remaining excavation, after removal of the capsule with the surrounding necrotic material measured approximately 2¼ inches in diameter, and about the same depth from the cortex. No portion of the ventricle was encountered. An intentional attempt at herniation of such an excavation in the brain as this had never been done to my knowledge. For this reason, the entire excavated area was loosely packed with fluffed iodoform gauze (Fig. 4). It was believed that this gauze would wall off the entire area, and that by slow removal of it after five or six days, herniation with obliteration of the cavity could be accomplished. The mastoid wound was likewise packed with fluffed iodoform gauze. Dakin tubes were inserted over the exposed area, all of which was covered with a rubber dam, and a copious

wet Dakin gauze dressing was applied, the incisions being left wide open. The ear, well covered with vaseline gauze, was included in the dressing. Report of the culture of the pus from the abscess: "Streptococcus hæmolyticus."

A note made following the operation was as follows: "The patient's condition upon leaving the table was good. The iodoform gauze will be left in position for five or six days until adhesions have taken place around the operative area, at which time they will be slowly removed and replaced. Just what will happen is not known. It is anticipated that there will be some herniation of this area with the possible carrying out of the

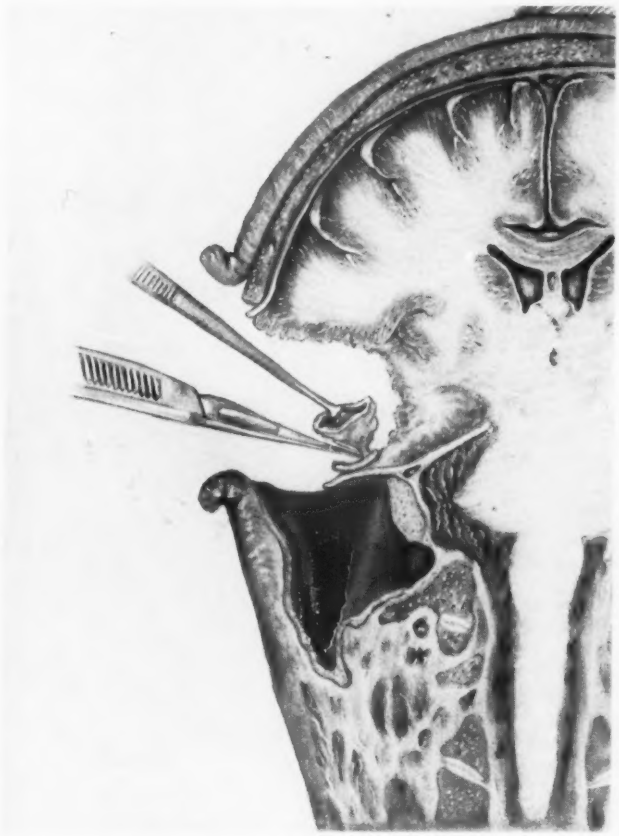

FIG. 3.—Transverse section showing the complete removal of the surrounding necrotic brain tissue. The capsule of the abscess has been partially removed and the remaining portion is being dissected away from its attachment to the basilar dura, leaving a small portion, which somewhat resembled an acorn cup, attached to the dura.

small remaining portion of the capsule attached to the basilar dura. This is the first time in the operator's experience that this method has been employed, and in this instance was used due to the fact that no other procedure could be carried out."

Post-operative Notes.—April 27, 1932, 1st dressing.—All of the dressing external to the rubber dam was removed leaving the original gauze (1) in the mastoid wound; (2) in the intracranial space originally occupied by the abscess and its surrounding necrotic brain tissue; (3) about the entire wound, *in situ*, without disturbing or loosening it. This mass of gauze makes a crater-like formation, in the centre of which shows

the outer surface of the iodoform gauze which was packed into the area formerly occupied by the abscess. This gauze moves with the pulsation of the brain. A very narrow crescentic margin of brain tissue shows on the superior border of the iodoform packing, but it has not actually herniated over it, due to its being held back by the dressing. There is a tendency for this herniation to increase while the dressing was being done. Rapid herniation is not desired, therefore a slightly compressive dressing consisting of wet Dakin gauze was again placed over the rubber dam and held with

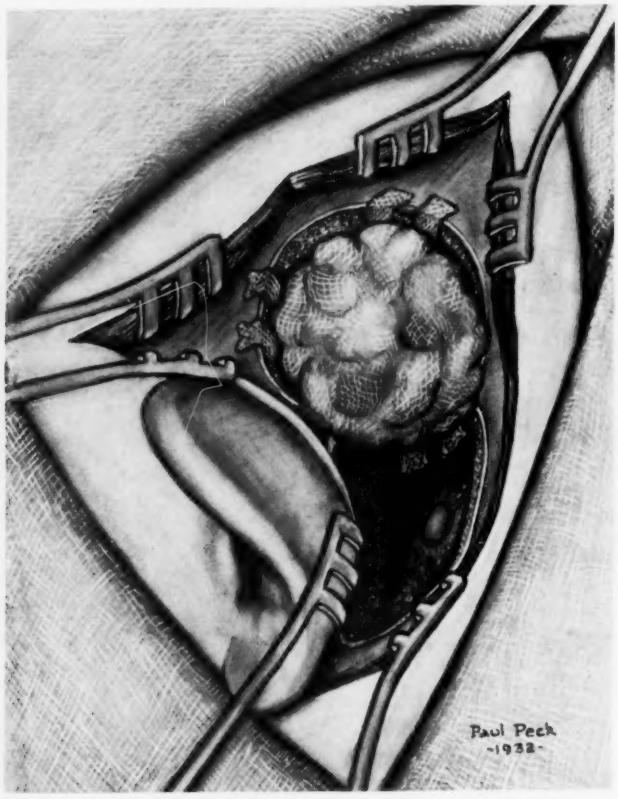

FIG. 4.—Lateral view of the operative site at completion of operation. The three flaps consisting of scalp, galea, temporal fascia and muscle are held with self-retaining retractors, the ear being displaced downward. The mastoid cavity is shown with an exposure of the lateral sinus in the posterior portion of the wound. The outer table of the skull is covered with pericranium. The excavation in the brain which resulted from removal of the abscess cavity and surrounding necrotic brain tissue, is packed with iodoform gauze. Three narrow strips of iodoform gauze have been insinuated between the cortex and the dura to prevent spreading of infection to the subdural space.

a snug bandage. General condition is good: Temperature 100° to 101°; pulse 96 to 104; respiration 20 to 22. Aphasia is increasing, which is to be expected. The patient is very quiet this morning with the use of codeine and sodium amytal. She is taking fluids well. Dressings were done daily or twice a day. Instillation of Dakin solution was done every hour. On April 28 the temperature increased to 102.4° following removal of some of the gauze about the scalp flaps.

April 30, 1932, 6th dressing.—All of the original iodoform gauze packing with exception of the strips placed about the dural margins were removed. During this

time there has been a slight but gradual herniation of the brain which has carried the gauze packing out with it. As the hernia gradually increased it also carried out the last remaining portion of the capsule which had been attached to the basilar dura so that it was completely outside the cranial cavity. A small gauze wick was inserted beneath the hernia at the site from which the small remaining portion of the abscess capsule had herniated, and the mastoid wound was packed with iodoform gauze. Dakin tubes were placed about the operative area so as not to press on the brain tissue, and the brain tissue, making up the most prominent portion of the hernia, was protected with a rubber dam and a similar dressing was applied. The brain tissue has taken on a healthier

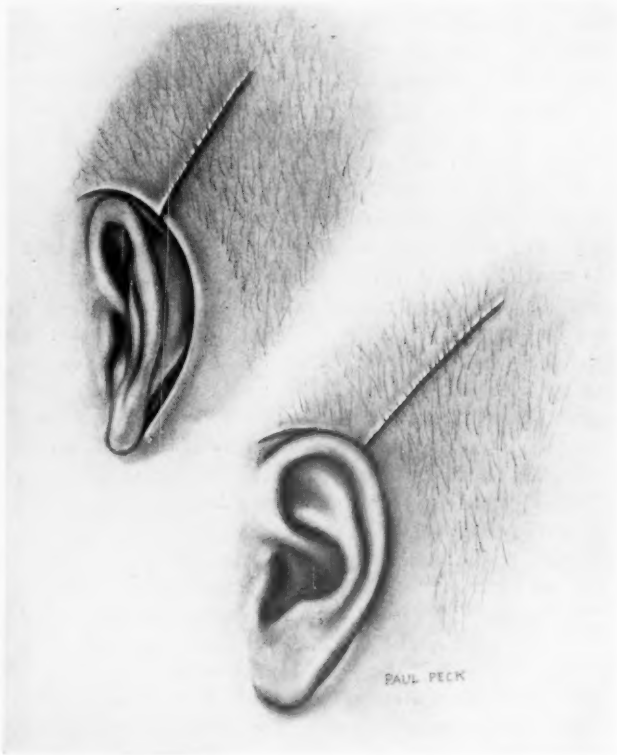

FIG. 5.—Operative site following scalp-plastic. The major portion of the scar is in hair-bearing scalp, and the remainder is inconspicuous behind the ear.

appearance and is becoming fibrosed. Patient's general condition is good: Temperature 99.8°; pulse 106; respiration 20.

May 1, 1932, 7th dressing.—All of the gauze strips about the dural margin and that in the mastoid wound were removed with but little difficulty. The entire area for the most part had a good appearance. The mastoid wound is clean, and the exposed area of the lateral sinus is beginning to cover with granulations. The herniation above has increased somewhat, but the basilar portion is about the same as yesterday. There was no pus present. There were a few superficial sloughs along the under surface of the scalp margin. Strips of gauze wet in Dakin solution were inserted between the scalp flaps down to the dural margins in order to allow of free drainage from the bone margin. A similar dressing was applied. The patient's general condition was not quite

so good as yesterday in the following respects: (1) The temperature rose to 102.4° at 9 A.M. dropping to 102.2° following the dressing. (2) Increased restlessness. This is believed to be due to the diminished amount of hypnotics and the increase in herniation. In other cases observed, restlessness was increased during the active herniation process. White blood-cells 14,000. Polymorphonuclears 79.6 (50.3 segmented, 25.3 band); lymphocytes 19.3; mononuclears 1 per cent. There is no rigidity of the neck, in fact there is less resistance to the passive movements of the neck than three days ago. The picture is not one of meningitis. 100 cubic centimetres of 50 per cent. glucose solution was given intravenously.

May 15, 1932: The dressing has been done daily. The wound is clean. The surface of the hernia is fibrosing more slowly than in cases in which the abscess cavity itself herniates and then forms the dome of the hernia. This I believe is due to the fact that little of the surrounding area is cortex, the major portion of the hernia is white matter, and no portion of the abscess wall goes to make up the herniating surface. The patient's general condition is very much improved. She is brighter, and her speech is improving. Anomia still persists but is also improving. The scalp margins have become well adherent to the lateral surface of the hernia, and epithelium has begun to spread on to the hernia itself.

May 20, 1932: The scalp about the wound was shaved and cleaned with benzine, and the hernia is now almost flat, with the edge projecting but slightly above the scalp surface. This was covered with perforated strips of adhesive which were carried across the surface of the hernia and fastened to the scalp. A slightly compressive wet Dakin dressing was applied for the purpose of gradually diminishing the size and height of the hernia. No lumbar puncture has been done up to the present time and there has been no leakage of cerebrospinal fluid through the hernia from the ventricle.

May 24, 1932: A lumbar puncture was done by Dr. Wortis with removal of 15 cubic centimetres of clear fluid in order to diminish the size of the hernia, and to allow it to subside to the level of the scalp, so that epithelialization of the hernial surface will be hastened. The surface of the hernia receded following the lumbar puncture to a level slightly below that of the scalp, and the protective perforated adhesive strips were applied over the hernia. Epithelialization is extending from the scalp margins.

June 14, 1932, Discharge Note.—The patient was discharged from the Hospital on the fiftieth day post-operative. The dressing has been done daily since the last note. Dressing consisted of removal of the perforated adhesive strips from over the granulating area, replacement, and covering the area with Dakinized gauze held with a bandage. The picture of the operative result presented at this time is as follows: There is a triangular area which measures about 3¼ inches along the anterior scalp margin, and about 4 inches along the posterior scalp margin down over the mastoid region, and about 3 inches along the scalp margin adjacent to the ear. This non-hair-bearing area was completely covered with epithelium with exception of a somewhat central area of granulating surface more or less arrowhead in shape, which measured in its horizontal direction about 1½ inches and in the vertical directions about ⅞ of an inch. There has been no bone margin sequestration. This area is somewhat lower than the scalp surface and it has never bulged since the lumbar puncture. The patient sat out of bed on May 31 for the first time, which was the thirty-sixth day post-operative. Temperature, pulse and respiration have remained normal. She sleeps well and eats well, walks well and has no headache. Her speech is improving.

This is the first case of a brain abscess which has come under my observation in which surrounding brain tissue outside of the abscess capsule (other than overlying cortex) was removed. One is unable to judge just how quickly speech will return completely. In other successful cases of left temporosphenoidal lobe abscess which I have

observed, the aphasia practically completely disappeared at varying post-operative periods.

June 29, 1932, 65th day post-operative; last dressing.—The granulating area has become completely covered with epithelium and is healed. There is now present a triangular shaped non-hair-bearing area which is somewhat cup shaped or depressed when the patient is in a sitting position, and is on a level with the scalp in a prone position. A scalp plastic with excision of the scar will be done one year later, and the entire area covered with normal scalp. Except for a partial anomia, she is apparently completely well. On November 7, 1932, a radical left antrum operation was performed by Doctor Faulkner. The patient was discharged on the fifteenth day post-operative. On April 12, 1933, a scalp plastic was performed at the New York Hospital. The scar was excised and the scalp flaps were brought together so as to cover the cranial defect with healthy scalp. This also "lifted" the drooping ear which had been present since the time of the operation. She was discharged on the twenty-second day post-operative. (Fig. 5.) She made apparently a complete recovery from the brain damage with exception of a slight anomia which is steadily improving.

Extirpation of the collapsed capsule of this abscess together with the surrounding necrotic brain tissue, and allowing a mild degree of herniation and subsequent hernial recession, resulted in complete healing in sixty-five days in this case.

The time may come when an attempt will be made to extirpate completely all encapsulated brain abscesses. Dr. Charles H. Frazier, in a recent conversation, stated that extirpation, or complete removal of the capsule may probably be the proper procedure in dealing with brain abscesses in the future. It is suggested that this procedure might be used in cases of acute or early brain abscess, when the condition is one of acute, suppurative encephalitis, uncomplicated by meningitis, and in which cases there is reason to believe that the condition of the patient will not allow the septic process to go on to proper encapsulation. There are such cases in which death may ensue before the brain can develop enough resistance to the infection to effect a walling-off or an encapsulation of the area. In this type of case the procedure described might enable one to remove the suppurative area in the brain. However, we must hope for greater refinements in our knowledge of the pathological physiology of brain abscess before we can pick such cases for early operation.

SUMMARY

A case is reported, giving the details of a successful procedure whereby a collapsed brain abscess wall, or "capsule," was extirpated, together with the surrounding necrotic, purulent brain tissue.

The suggestion is made that this procedure may one day be utilized in certain suitable cases of suppurative encephalitis or "phlegmon" of the brain, in which there is but little tendency to encapsulate; in which Nature does not seem to be able to limit the infection.

When possible, a brain abscess should be so dealt with as to remove it entirely by resorting to herniation rather than mere drainage, which frequently leaves a residual septic secondary abscess focus.

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DEFORMATION OF THE SELLA TURCICA BY TUMORS IN THE PITUITARY FOSSA

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The Röntgen examination of the sella turcica is regarded as essential and a procedure to be employed routinely in the investigation of tumors arising within the pituitary fossa. The present study was undertaken to determine the frequency and diagnostic value of the changes produced in the sella turcica by such tumors. For this purpose seventy-four cases from the service of Dr. Charles H. Frazier were critically analyzed. These cases were verified either operatively or at post-mortem examination.

It is generally recognized that tumors located in any part of the intracranial cavity may produce changes in the sella turcica. The character of the changes produced is to some extent influenced by the location of the lesion. It is possible, therefore, in many instances, to indicate the approximate location of the tumor by the type of deformity that has occurred. In the case of intrasellar neoplasms, the alteration of the sella is usually sufficiently characteristic to indicate the precise position and often the nature of the tumor.

Röntgenological Technic.—To be of diagnostic value, considerable care must be exercised in making röntgenograms of the sella turcica. Technically the films should be as nearly perfect as possible. This is of importance, since films lacking in detail may fail to reveal changes essential to proper interpretation. The use of the Potter-Bucky diaphragm is a great aid. The view should be an absolutely true lateral with bilateral structures superimposed. For this purpose films are best made with the patient either in the erect position or lying on his back with a Bucky diaphragm adapted for these positions. Films made with the patient prone and the head turned in the lateral position rarely result in a true lateral view. Stereoscopical films are very helpful, especially in cases showing greater involvement on one side of the sella than on the other. If it is desired to use one of a stereoscopical pair of films for measuring the size of the pituitary fossa, it will be found that neither is a true lateral, since the stereoscopical shift carries the tube to either side of the middle of the fossa. This objection can be overcome by making the first film a true lateral and then moving the tube the full length of the stereoscopical shift either forward or backward. This gives a somewhat distorted image, when viewed stereoscopically, but results in one film being a true lateral, and, when made at a sufficient distance, this film can be used to measure the size of the pituitary fossa. We do not believe, however, that the slight variation resulting in stereoscopical films made in the usual manner will alter the size of the fossa sufficiently to be of any clinical importance. At times, it is very helpful to cone down upon the sella, using intensifying screens without the Bucky diaphragm. While this is the routine practise of some radiologists, there should be made, in addition, a lateral of the entire skull, as not infrequently changes are encountered somewhat removed from the region of the sella, which may be of considerable diagnostic importance.

Since an alteration in the size of the pituitary fossa is one of the cardinal changes occurring in intrasellar tumors, it is necessary that the exposures be made at a film target distance sufficiently great to minimize the enlargement resulting from divergent rays. Röntgenograms made at distances of thirty-six inches or more are satisfactory for this purpose.

The Röntgen diagnosis of intrasellar tumors seldom, if ever, depends solely upon a simple enlargement of the pituitary fossa, and, as this study will show, alterations in size may be absent or extremely slight. The size of the fossa is of such importance, however, as to make it necessary to be familiar with the measurements of the normal pituitary fossa. In the average adult skull, the normal measurements are 8 millimetres in depth and 10 millimetres in the anteroposterior diameter. Fossæ of smaller size appear to be

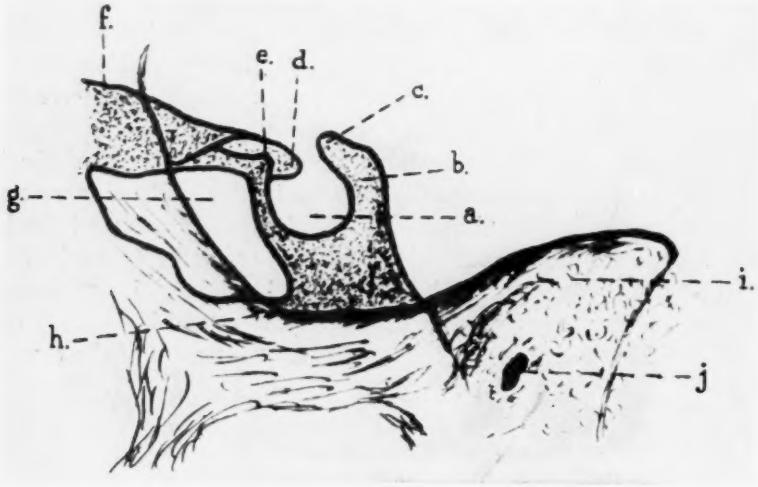

FIG. 1.—Drawing to show the important parts of the sella turcica and adjacent structures as seen in a lateral röntgenogram of the skull: (a) pituitary fossa; (b) dorsum sellæ; (c) posterior clinoid process; (d) anterior clinoid process; (e) tuberculum sellæ; (f) floor of anterior cranial fossa; (g) sphenoid sinus; (h) floor of middle cranial fossa; (i) superimposed mastoid and petrous portions of the temporal bone; (j) external auditory meatus.

of no clinical significance. Those measuring 10 millimetres by 12 millimetres are regarded as top normal, while those of larger dimensions are distinctly abnormal.

The cardinal changes occurring in deformations of the sella turcica, regardless of the location of the tumor, are: (1) atrophy of the dorsum sella, (2) erosion of the floor of the pituitary fossa, (3) increase in the size of the fossa. In intrasellar tumors, all three are found in the majority of cases. Various minor alterations may also occur. These, along with the cardinal changes, will be considered in some detail.

The Dorsum Sellæ.—The changes occurring in the dorsum sellæ (Fig. 1) are of particular importance. The Röntgen diagnosis frequently is dependent upon the presence or absence of this structure. In the typical deformity (Fig. 2), the dorsum assumes a very characteristic appearance. There is

always definite evidence of erosion of the anterior surface so that it becomes much thinner than normal. The concomitant erosion of the floor of the pituitary fossa gives to the dorsum sellæ an appearance of elongation. Not infrequently is it actually pushed backward. It thus assumes a position which is much more erect than normal. This appearance of elongation and erect position is not found in any other type of deformity. Of prime importance, however, is the retention of the posterior clinoid processes. These small osseous protuberances from each lateral aspect of the upper surface of the dorsum sellæ, so prone to disappear with extrasellar lesions, will usually remain intact, even though the pituitary tumor has become of enormous size. It is for this reason that their retention is of so much diagnostic value.

As an intrasellar tumor enlarges, atrophy of the dorsum sellæ may proceed to a complete disappearance of the structure. It is surprising, however,

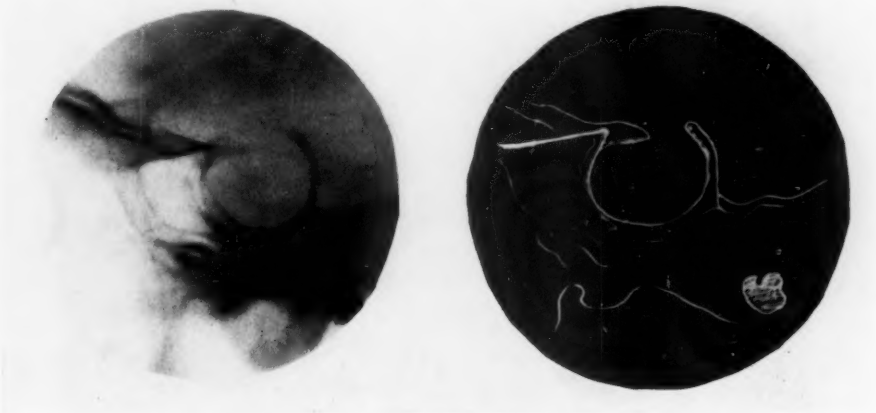

FIG. 2.—The characteristic deformation of the sella turcica resulting from an intrasellar tumor. Left, original röntgenogram; right, drawing made from the röntgenogram.

the size that these lesions may assume before complete erosion of the dorsum occurs. With its complete disappearance, the sellar deformity becomes less characteristic of a pituitary tumor, as this occurrence is found more commonly in extrasellar tumors, especially those arising in the posterior fossa. It is seen, therefore, that an intact dorsum sellæ and retention of the posterior clinoid processes are of the utmost diagnostic importance.

Occasionally, the dorsum sellæ as the result of erosion become so faint as to be hardly perceptible. It is for this reason that the röntgenogram should present the best possible detail. Not infrequently, the dorsum, because of its extreme posterior position, becomes partially obscured by shadows superimposed upon it. Such shadows may result from the pinna of the ear or from mastoid cells that have extended forward into the squamous and zygomatic portions of the temporal bone. It is essential, therefore, that diligent search be made for the dorsum sellæ, as it may be the one point necessary to give certainty to the Röntgen diagnosis of an intrasellar tumor.

An analysis of the effect produced upon the dorsum sellæ in the series of cases studied revealed evidence of alteration in seventy-two or 97.3 per cent. In only two instances or 2.7 per cent. was the dorsum normal in appearance. As to the degree of erosion, in 2.7 per cent. the change was slight, in 10.8 per cent moderate, in 75.7 per cent. there was marked erosion, while in five cases or 8.1 per cent. there was a complete absence of the dorsum sellæ. Regarding the posterior clinoid processes, in thirty-eight cases or approximately 50 per cent. these structures were still present.

Floor of the Pituitary Fossa.—The second of the cardinal changes, namely, erosion of the floor of the pituitary fossa, is almost an invariable accompaniment of intrasellar tumors. Occasionally, this is but slight; usually, however, it is quite marked. Erosion of the floor manifests itself chiefly

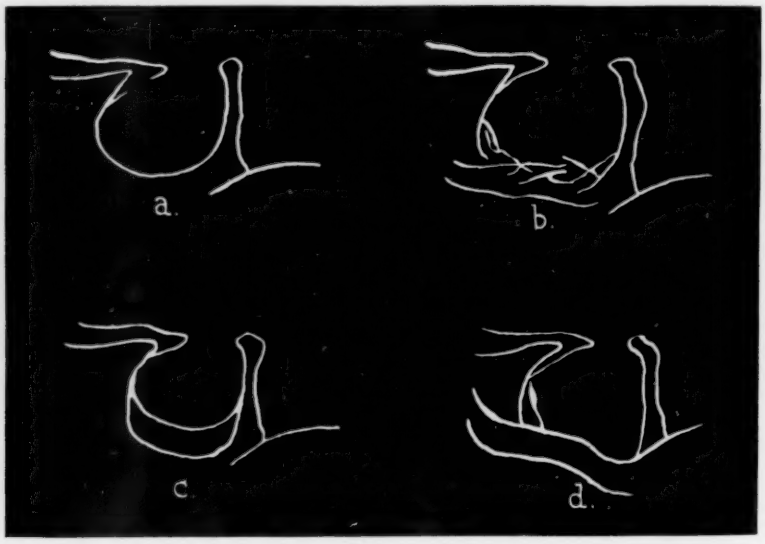

FIG. 3.—The cases in this series were divided into four groups according to the appearance of the floor of the pituitary fossa: (a) although eroded the floor has maintained the appearance of a normal fossa, 19 per cent.; (b) the appearance of multiple broken lines, 39.1 per cent.; (c) the double floor, 17.6 per cent.; (d) disappearance of the floor due to erosion below the level of the floor of the middle cranial fossa, 24.3 per cent.

in a definite enlargement of the pituitary fossa. The appearance of the floor may vary considerably in the individual case. The floor of the normal fossa presents a sharp, distinct, unbroken line which curves gently downward from the olivary eminence, or tuberculum sellæ, to the base of the dorsum sellæ. This line is usually quite dense having the Röntgen characteristics of cortical bone. The cases in this series were divided into four groups (Fig. 3) according to the appearance of the floor. In the first, representing 19 per cent., the floor presented the appearance of a normal fossa. Although there was evident erosion, as denoted by the increase in size of the fossa, the outline of the floor, nevertheless, remained sharp and distinct. The second group, 39.1 per cent., presented a floor difficult of delineation. The floor appeared to be

made up of multiple broken lines so that it was difficult to determine its true level. In the third group, 17.6 per cent., there was the appearance of a double floor. By careful study, one could determine, in these cases, a greater destruction of one side of the sella than of the other, denoting a lateral spread of the tumor into the adjacent middle cranial fossa, the so-called parasellar extension. These present a very interesting group of hypophyseal tumors, cases in which the sellar deformity may be more characteristic of a parasellar than an intrasellar lesion. Clinically, these cases are often less characteristically pituitary in origin, presenting a homonymous hemianopsia rather than the usual bitemporal hemianopsia. In the fourth group, 24.3 per cent., there seemed to be a complete disappearance of the floor. In these cases, there was such marked erosion that the floor was apparently below the level of the middle cranial fossa. In some instances, there was apparently a complete absence of osseous tissue between the pituitary fossa and the sphenoid sinus. In these cases the pituitary gland appeared to be suspended in the sinus.

Sphenoid Sinus.—As a result of the erosion of the floor of the pituitary fossa, there is more or less encroachment upon the sphenoid sinus. In very large tumors, there may be complete obliteration of this sinus. This is, however, not necessarily dependent upon the size of the lesion as some tumors show a distinct tendency to downward growth, as others may grow upward or laterally. In this connection, Pancoast is of the opinion that the size of the fossa is in a large measure dependent upon whether the body of the sphenoid bone is osseous in nature or occupied by a large sphenoid sinus. He believes that the greatest erosion of the floor occurs in those cases in which the body of the sphenoid bone is osseous rather than pneumatized by a large sphenoid sinus.

The extent of encroachment on the sphenoid sinus was formerly of more practical importance than at present. In the days when the surgical approach to hypophyseal tumors was by way of the trans-sphenoidal route the neurosurgeon was much concerned with the degree of involvement of this sinus. It became possible to remove a much larger portion of the tumor when it had encroached to a considerable extent upon the sphenoid sinus. For a time, the sphenoid sinus also served as the portal of entry for post-operative irradiation. A 50-milligram radium capsule attached to a long wire applicator was inserted through the nose into the sphenoid sinus and permitted to remain there for six hours. This procedure was in vogue at a time when little was known regarding the value of heavily filtered radiation. The effect obtained with capsules of 0.5 and 1 millimetre of silver could hardly have done more than scorch the surface of the tumor, in addition to inviting infection by its necrotizing effect. The present-day applicators of 2 millimetres of platinum inserted into the sphenoid sinus might have much to offer in reducing the size of intrasellar tumors. This could be employed in conjunction with the modern transfrontal extirpation of hypophyseal tumors.

Enlargement of the Pituitary Fossa.—The third cardinal change, namely, increase in size of the pituitary fossa, is one of the outstanding characteristics

of intrasellar tumors. This enlargement results from the marked erosion occurring in the floor of the fossa and the anterior surface of the dorsum sellæ. Since this erosion usually takes place equally in all directions a uniform enlargement results, which gives to the fossa a ballooned-out appearance such as is seen in no other type of sellar deformity. As a rule, the largest fossæ encountered are those resulting from primary intrasellar tumors.

In the present series a detailed study was made of the size of the pituitary fossa. In many instances, because of the marked erosion, it was not possible to secure accurate measurements. In most cases, however, approximate measurements could be obtained, and these gave some idea as to the relative size of the fossæ. Measurements were obtained in sixty-eight of the seventy-four cases, and in these the average size of the fossæ was 22 millimetres anteroposterior and 16 millimetres in depth. This is in marked contrast to the 10 and 8 millimetres respectively for the normal adult fossa. The smallest fossa measured 10 by 7 millimetres, while the largest was 36 by 25 millimetres. In only two cases was there no enlargement. Thus, in this series, 97.3 per cent. showed a definite increase in size of the pituitary fossa.

Anterior Clinoid Processes.—Changes less constant and characteristic were found in the anterior clinoid processes and the tuberculum sellæ. The various appearances presented by the anterior clinoid processes, with the percentage of each (Fig. 4). In 23 per cent. of cases, the anterior clinoid processes appeared to be elongated, although normal in other respects. This appearance of elongation is the result of the marked erosion of the anterior surface of the pituitary fossa causing more of the process to come into view as seen in the lateral röntgenogram. In the largest group of cases, 37.9 per cent., the process appeared not alone to be elongated, but there was definite evidence of erosion of its under surface producing a considerable narrowing of the process. In some instances, this erosion was so marked as to give to the process a sickle-shaped appearance. Inasmuch as the anterior clinoid processes are located some distance lateral to the pituitary fossa, a hypophyseal tumor must become of considerable size before encroaching upon these structures. A short stubby anterior clinoid process was found in only five, or 6.8 per cent. of cases. In a group comprising 18.9 per cent. of cases, there was noted a much greater effect on one process than on the other, and in these the most involved process showed a tendency to upward tilting. Such a finding is indicative of a unilateral extension into the adjacent middle cranial fossa. Such lesions may be mistaken for temporal lobe tumors as they not infrequently give rise to symptoms suggestive of such a localization. The determination of the side to which the tumor is extending as denoted by the greater involved anterior clinoid process is at times helpful in the surgical approach to the tumor.

Tuberculum Sellæ.—Changes in the appearance of the tuberculum sellæ will be found in the majority of cases of intrasellar tumors. Normally the tuberculum presents a rounded blunt appearance (Fig. 1). When deformed by a pituitary tumor, it becomes characteristically pointed. At times, it

appears to be actually pushed upward and forward (Fig. 4). This appearance results from the marked erosion which occurs on the anterior wall of the pituitary fossa and which at times shows a definite tendency to undermine the tuberculum sellæ. In this series of cases 58.2 per cent. showed changes in the tuberculum sellæ.

Considering the changes found in the sella turcica in this series, definite alteration in structure was present in every instance. The appearance of the sella permitted the cases to be divided into three groups. Group 1, those cases presenting the characteristic appearance of an intrasellar lesion; group 2, those in which the deformity was merely suggestive; group 3, atypical deformations. In the first group, there were fifty-five cases or 74.3 per cent.

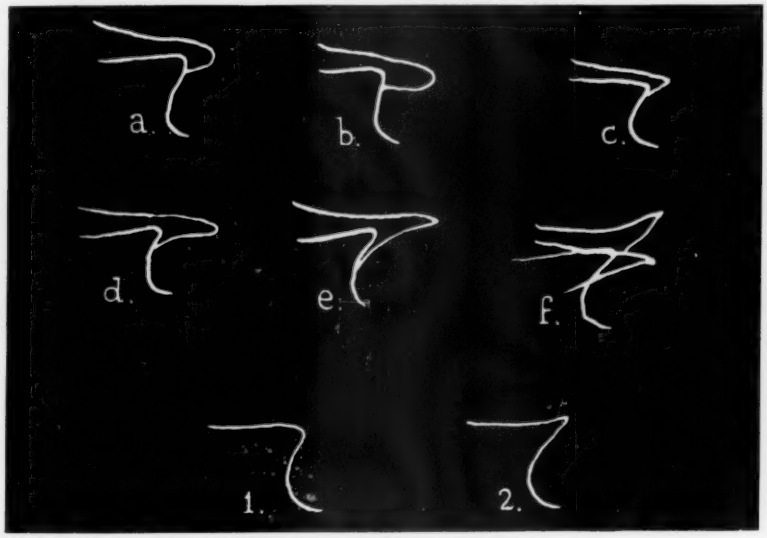

FIG. 4.—Alterations in the anterior clinoid processes and the tuberculum sellæ (a) normal anterior clinoid process, 13.4 per cent.; (b) elongation, 23 per cent.; (c) shortened, 6.8 per cent.; (d) elongated and eroded, 37.9 per cent.; (e) sickle-shaped; (f) greater effect on one process than on the other, 18.9 per cent. 1. Normal tuberculum sellæ; 2. characteristic deformation of the tuberculum, 58.2 per cent.

In these, the deformity was sufficiently characteristic to warrant a diagnosis of pituitary tumor from the Röntgen findings alone. The second group comprised twelve cases, 16.2 per cent. The deformity, while suggestive, was not sufficiently characteristic to permit of a Röntgen diagnosis of an intrasellar tumor. Correlation with the clinical data, however, left little doubt as to the location of the lesion. There were seven cases in the third group, 9.5 per cent. In these, the deformity was atypical, quite unlike that produced by a pituitary tumor. In three instances a complete absence of the dorsum sellæ gave the appearance commonly seen in posterior fossa tumors. In three others, the deformity suggested a tumor of the middle cranial fossa. In the remaining case, a metastatic adeno-carcinoma, the destruction of the sella was so extensive that the deformity must of necessity have been due to

a lesion in or about the sella. Its intrasellar origin, however, could not be recognized röntgenographically.

The changes produced in the sella turcica by intrasellar lesions depend upon the nature of the tumor, the rapidity of its growth and the direction of its extension. The vast majority of such tumors are adenomata. The pathological diagnosis in this group of cases is as follows: adenoma sixty-one, simple hyperplasia two, craniopharyngioma two, metastatic adeno-carcinoma one, teratoma one, and no pathological report seven.

The Pituitary Adenoma.—The adenomata produce the typical enlargement and deformity of the sella turcica so characteristic of intrasellar lesions. The slowness with which these tumors usually grow permit the various structures of the sella to remain intact and to maintain clear-cut and sharp outlines. In some instances, the density of the bone suggests that the pressure of the growing tumor has stimulated new bone formation in an apparent attempt to maintain the integrity of the sella. This can, of course, occur only in the more slowly growing tumors. In those lesions of more rapid growth, the erosions which occur are more irregular giving rise to vague, indefinite outlines. In addition, there is frequently considerable decalcification. This accounts for the appearance of multiple lines so commonly seen in the floor of the pituitary fossa.

Of the sixty-one adenomata, fifty produced changes typical of an intrasellar lesion. In these cases, the diagnosis of a pituitary tumor was possible from the Röntgen examination alone. In eight instances, the deformity was suggestive but only after correlation with the clinical data was a diagnosis of pituitary tumor justifiable. In three cases, the deformity was atypical. In one of these, the appearance suggested a parasellar lesion, and in the other two the changes were more characteristic of a posterior fossa tumor. This latter type of deformity is prone to occur in very large adenomata in which there is a complete destruction of the dorsum sellæ. In such cases one must rely for a correct interpretation upon the clinical data and upon an absence of the Röntgen manifestations of increased intracranial pressure, which are usually present in posterior fossa lesions.

Röntgenographically, cystic tumors are regarded as more capable of producing erosion of bone than are those of a solid nature. This is due to the fact that they readily transmit pulsations from adjacent blood-vessels. Pulsating lesions, such as aneurisms, are notorious for their ability to erode bone. In the group of adenomata, there were nineteen cystic tumors. Contrary to what might have been expected, these lesions produced less effect upon the sella turcica than did the solid tumors. As a group, there was definitely less enlargement of the pituitary fossa.

In five cases, the pathological report indicated that the adenoma was of the basophilic variety. None of these patients clinically presented the basophilic syndrome of Cushing. One patient was definitely acromegalic. There was nothing characteristic in the Röntgen appearance of the sella turcica in these cases. Three presented the typical deformity of a pituitary adenoma,

the other two were merely suggestive. As a group, the enlargement of the fossa was greater than the average for the entire series. In such a small number of cases, however, this was probably a mere coincidence.

Acromegaly.—Eight patients in this series presented definite evidence of acromegaly. In seven, the alteration in the sella turcica was typical of a pituitary adenoma, the remaining one was suggestive. There was nothing in the sellar deformity to indicate that the patients were acromegalic. Most of them presented other evidences in the skull suggestive of this condition, such as an increased prominence of the supra-orbital ridges, large paranasal sinuses, increased thickness of the skull and overdevelopment of the mandible.

Fröhlich's Syndrome.—In six patients, the physical examination was suggestive of Fröhlich's syndrome. Five presented a characteristic deformity of the sella and one was suggestive. In other respects, the sellar deformity was essentially the same as for the entire group of adenomata. There was nothing characteristic in the skull of these patients.

Lesions Other Than the Adenomata.—In the two cases of hyperplasia, one presented a typical sellar deformity, while the other was merely suggestive. There was nothing in the Röntgen appearance to distinguish these cases from the adenomata. In neither of the two cases of craniopharyngioma was the sellar deformity typical, although both were suggestive of intrasellar lesions. In the metastatic adeno-carcinoma, the deformity was quite atypical. The exact origin of the lesion could not be recognized röntgenographically. In the single example of a teratoma, the alteration was quite characteristic of an intrasellar tumor. This lesion showed evidence of marked erosion with considerable enlargement of the fossa. The dorsum sellæ and posterior clinoid processes, however, remained intact.

The direction of growth of a pituitary tumor is one of the important factors in determining the appearance of the sella turcica. The fact that the vast majority of deformities produced by intrasellar lesions conform to a rather characteristic pattern in which the pituitary fossa is uniformly enlarged would indicate that these tumors for the most part grow symmetrically in all direcions. Further evidence of this fact is the bilateral involvement of the anterior clinoid processes. That this growth, however, is not absolutely equal in all directions is recognized by the variations in the involvement of the optic chiasm. In most instances failure of vision in one eye is in advance of the other and may proceed to complete blindness before much effect is noted in the opposite eye. This no doubt accounts for the large number of sellar deformities showing evidence of greater involvement of one side than the other. This occurred in 22 or 29.7 per cent. of the cases in this series. In some instances, there is a definite unilateral extension into one of the middle cranial fossæ. These lesions give rise to a double floor, involvement of but one anterior clinoid process or unilateral erosion of the dorsum sellæ. Symptoms in these cases sometimes suggest a lesion of the temporal lobe, and occasionally the sellar deformation is more characteristic of a para than an intrasellar tumor. At times, it is impossible to determine either

röntgenologically or clinically the exact origin of a tumor in this position. In this series, eight cases presented definite temporal lobe symptoms, such as a homonymous hemianopsia or uncinate fits.

Lesions which grow directly upward are likely to produce the least change in the sella turcica. This is due to the early involvement of the optic chiasm causing visual disturbance, in consequence of which the patient seeks medical attention early. A small tumor by upward extension may press upon the chiasm before causing much enlargement of the pituitary fossa. This no doubt is one explanation for the rare occurrence of a normal sella turcica in the presence of a pituitary tumor. In this connection, one must take into account the variable position of the optic chiasm, as described by de Schweinitz in his admirable Bowman Lecture of 1923. He reported the position of the chiasm in a series of bodies as follows: In 12 per cent. the entire chiasm was directly over the hypophysis; in 5 per cent. the chiasm occupied an anterior position, only the dorsal part rested over the pituitary gland; in 79 per cent. the chiasm was situated somewhat posteriorly, with the dorsal part resting upon the dorsum sellæ, and in 4 per cent. the entire chiasm was upon and projected behind the dorsum. The position of the optic chiasm will readily influence the ease with which this structure is pressed upon and, therefore, govern the time of onset and also the nature of the visual disturbance, the symptom most commonly responsible for the patient seeking medical attention.

Of considerable importance in the röntgenological recognition of hypophyseal tumors is the complete absence of other Röntgen manifestations of an intracranial neoplasm. In only two instances were changes found not ordinarily associated with pituitary tumors. Evidences of increase in intracranial pressure, such as convolutional atrophy involving the inner table of the bones of the vault, widening of the sutures and thinning of the bones of the skull, are seldom encountered. Occasionally, in very large pituitary tumors, sufficient encroachment upon the ventricular system may occur to produce an internal hydrocephalus, in consequence of which Röntgen manifestations of increased intracranial pressure occur. Such changes were found in the two cases previously referred to. Calcification, of such value in the detection of intracranial neoplasms, was encountered in but one instance in this series. This occurred in one of the two cases of craniopharyngiomas. In such lesions, calcification is a very common occurrence. Since most craniopharyngiomas occupy a suprasellar position, evidence of calcification serves to differentiate suprasellar from primary intrasellar growths. Other signs such as localized hyperostoses and lateral shifts of the pineal body do not occur in intrasellar lesions.

In those cases in which the deformation of the sella is not of the characteristic type and especially when there has been a complete disappearance of the dorsum sellæ, an absence of other röntgenological signs is most helpful in localizing the lesion in the pituitary fossa. Extrasellar tumors producing

marked deformity of the sella seldom fail to produce other Röntgen evidences of an intracranial tumor.

Of the various types of deformation of the sella turcica produced by neoplasms within the cranial cavity that resulting from an intrasellar tumor is the only one which is in any way pathognomonic. In the majority of instances, this alteration is sufficiently characteristic to establish the diagnosis of a pituitary tumor. In less characteristic deformities, correlation with the clinical data leaves little doubt as to the diagnosis. A Röntgen examination of the sella turcica is indicated in every suspected case of hypophyseal tumor. The question arises as to whether surgical treatment for a pituitary tumor is ever justifiable in the absence of definite sellar changes. While a tumor requiring surgical intervention may exist without deforming the sella turcica, this occurrence is so rare that the clinical evidence must furnish positive proof of such a lesion before surgery is warranted. A characteristic alteration in the structure of the sella turcica along with the manifestations of pituitary dysfunction and a characteristic bitemporal hemianopsia afford the evidence upon which a clinical diagnosis of a pituitary tumor is based.

SUMMARY

1. The röntgenological manifestations in a series of seventy-four verified intrasellar tumors were critically analyzed. Definite deformation of the sella turcica occurred in every instance, 100 per cent.

2. A detailed description is given of the character and frequency of the various changes encountered.

3. The changes produced in the sella turcica by intrasellar lesions depend upon the nature of the tumor, the rapidity of its growth, and the direction of its extension.

4. A correlation is made between the histological nature of the tumors of this series and the type of sellar deformity produced.

5. In approximately 75 per cent. of the cases of this series and 82 per cent. of the adenomata, the deformation of the sella turcica was sufficiently characteristic to be regarded as pathognomonic of a pituitary tumor.

THE CUTANEOUS DISTRIBUTION OF THE TRIGEMINAL NERVE

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of New York, N. Y.

An active interest in the skin distribution of the trigeminal nerve has led to a more detailed analysis than that of two decades ago (Kraus[1]). It has become evident that, in addition to the two well-recognized areas of distribution of the trigeminal nerves to the skin of the head and face—one the peripheral and the other the central or segmental—there are two other more fundamental areas of distribution which can be described. One is obtained by the division of the cutaneous area of the trigeminal nerve into dorsal and ventral parts (Fig. 1), the other by the division of this same area into more or less headward (or tailward) parts.

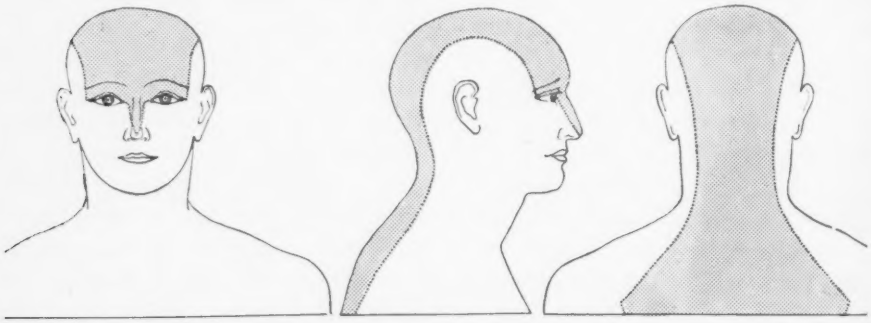

Fig. 1.—The division of the surface of the head into dorsal and ventral areas. The dorsal area is shaded.

Once these have been established, the four types of distribution can be compared each with the other to reach a better understanding of the entire distribution of the trigeminal nerve, not only to the skin but also to other structures of the head.

DIVISION OF THE CUTANEOUS DISTRIBUTION OF THE TRIGEMINAL NERVE INTO DORSAL AND VENTRAL AREAS

Except in the region of the eye and ear, it is easy to draw the lines which divide the surface of the body into dorsal and ventral areas. There is one on each side of the back of the body. Each line begins at the mid-line near the tip of the nose, then passes backward, rises over the pinna of the ear, goes caudally on the back of the body to the region of the hip and then turns towards the mid-line to meet its fellow over the region of the coccyx (Fig. 2).

On the side of the nose this line follows the boundary between the two great divisions of the trigeminal nerve, one dorsal, the area supplied by the ophthalmic nerve, the other ventral, the area supplied by the maxillo-

mandibular nerve (Fig. 3). It is now well known from comparative anatomical studies that the trigeminal nerve is really bigeminal.

At the eye, we find the dorsoventral line passing from the inner to the outer canthus (Fig. 1). However, we know that the optic nerve and the

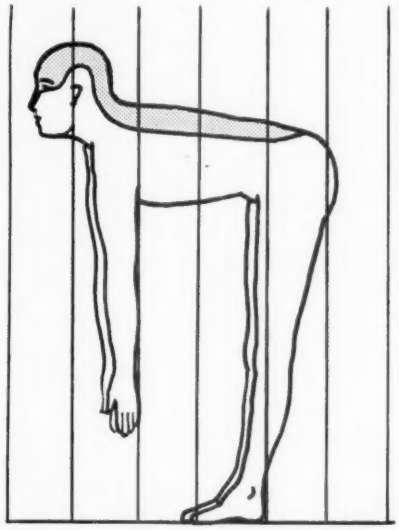

FIG. 2.—The general horizontal direction of the dorsoventral dividing line and the general vertical direction of the segments of the body (after Monrad-Krohn,[2] modified). The dorsal area is shaded.

eyeball are dorsal structures. Consequently, some explanation must be found of this seemingly incorrect location of the dorsoventral dividing line, seemingly incorrect since it seems to pass *through* a dorsal structure not *beneath*

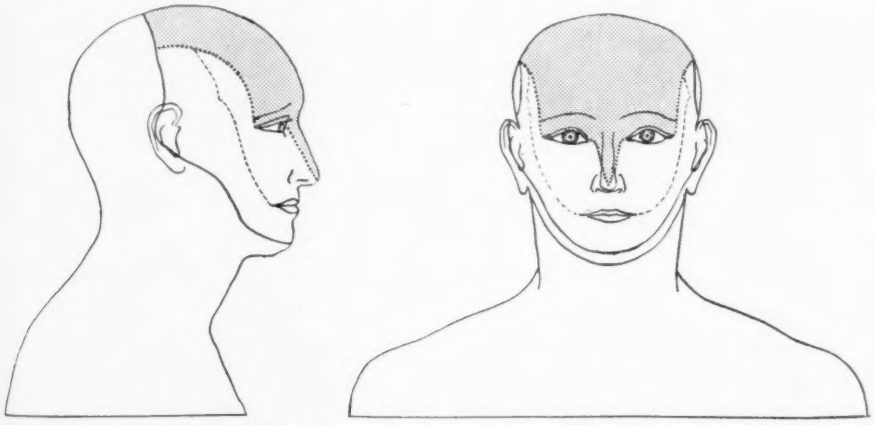

FIG. 3.—The bigeminal division (by dots) of the trigeminal nerve area. The further subdivision of the ventral maxillo-mandibular nerve is indicated by dashes (after Dejerine,[3] modified). The dorsal area is shaded.

it. In fish we find that the distribution of the branches of the trigeminal nerve is not like that in the higher vertebrates: the amphibians, the reptiles

and the mammals (man included). The ophthalmic nerve divides into two branches (Fig. 4). One supplies the region dorsal to the eye, the other the region ventral to the eye (Fig. 4). In animals higher than fish in the evolutionary scale the region ventral to the eye is supplied by the maxillo-mandibular nerve. What accounts for this difference between fish and higher animals? The appearance in animals higher than fish of the lachrymal apparatus, a connection to the nose (a ventral structure, whether considered a "mouth for gases" or a smell apparatus) seems to have brought with it an alteration of the innervation of the skin which surrounds the eye, so that the ventral part of this skin area is supplied by the ventral maxillo-mandibular nerve rather than by the ventral part of the dorsal ophthalmic nerve. With these facts in mind, it is not difficult to understand why the dorsoventral dividing line passes through rather than below the dorsal eye area (Fig. 1).

Caudal to (or back of) the outer canthus, the line is still more difficult to determine. Almost every authoritative text, whether anatomical or neurological, gives a different version. Of course, much copying has occurred,

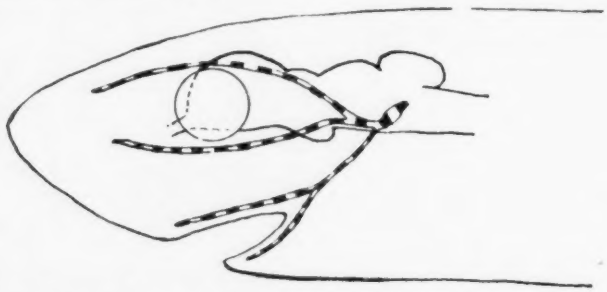

FIG. 4.—To show that in fish the trigeminal nerve is composed of two main branches, the ophthalmic (dorsal) and the maxillo-mandibular (ventral). Each of these nerves has two branches. The ventral branch of the dorsal ophthalmic nerve supplies the region ventral to the eyeball (after Kingsley,[4] modified. See also Kingsley,[4] p. 186).

so that the number of versions which have been found is not greater than four. Further, in Gregory's[5] now classical analysis of the face, we find another version (see his Fig. 118, copied from Stockard) which is quite different from the foregoing. Stockard's figure shows the line running *through* the ear at the outer end of the external auditory meatus, while the anatomical and neurological texts show it at various places *above* the pinna of the ear.

The auditory apparatus has developed from the labyrinthine, the labyrinthine apparatus has developed from the lateral line system of fish and lower amphibians and this last structure divides dorsal from ventral body areas. Consequently, one surface of a plane dividing the dorsal from ventral parts of the body should touch some point along the bony canals which are traversed by the auditory nerves. But the skin line, which is the skin surface edge of the plane, does not follow this course. This edge curves upward from the outer canthus above the ear, and then turns down on the back of the neck (Fig. 1).

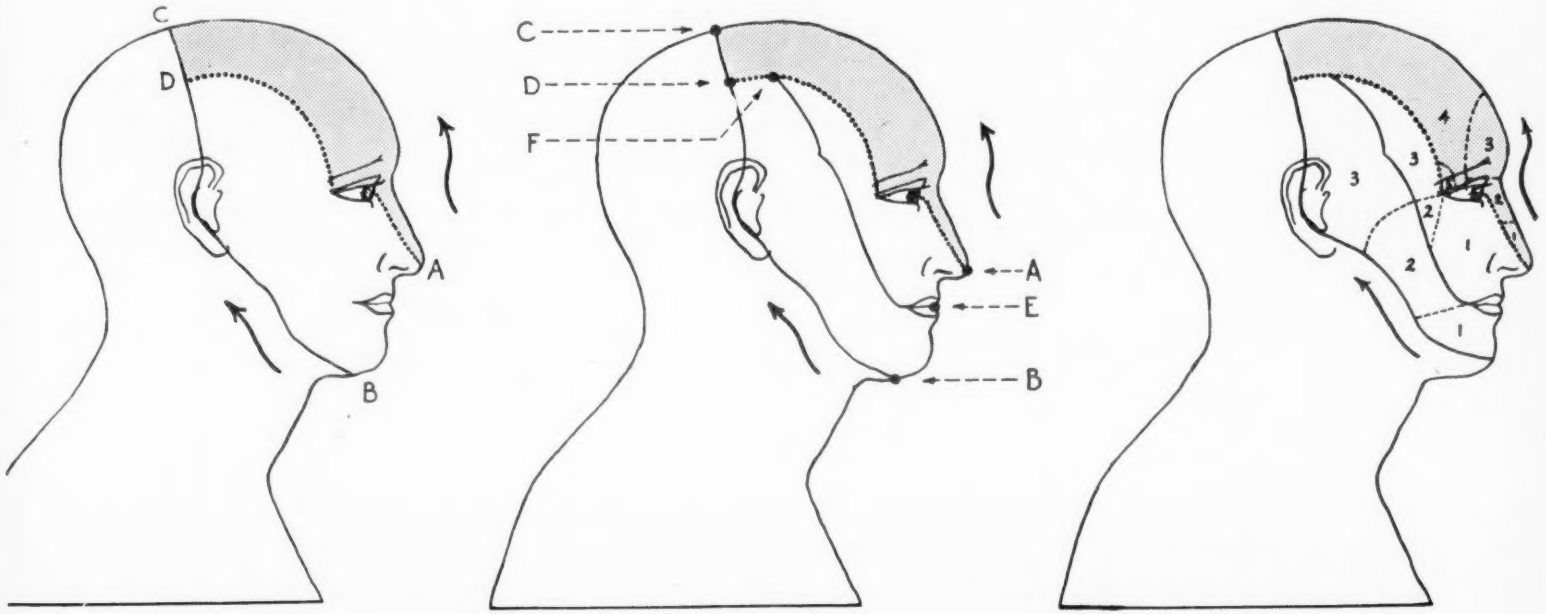

FIG. 5.—The three degrees of division of the trigeminal nerve area. The arrows indicate a general cephalo-caudal direction. The smallest divisions of the trigeminal nerve are shown in the right hand figure.

I. Ophthalmic Nerve
1. Nasal nerve.
2. Infratrochlear nerve.
3. Supratrochlear nerve.
4. Supra-orbital nerve.
5. Lachrymal nerve.

II. Maxillary Nerve
1. Infra-orbital nerve.
2. Temporomalar nerve. Malar branch.
3. Temporomalar nerve. Temporal branch.

III. Mandibular Nerve
1. Mental nerve.
2. Buccal nerve.
3. Auriculotemporal nerve.

Compare with Fig. 6. See text also. The dorsal area is shaded.

The pinna of the ear lies entirely in the ventral field rather than on the dorsoventral dividing line (Fig. 1). Again a search for reasons has been made. Probably one of these is the appearance of the connection between the nose and the ear, the Eustachian tube, which appeared in animals higher than fish. This new connection has converted the ear region into one which

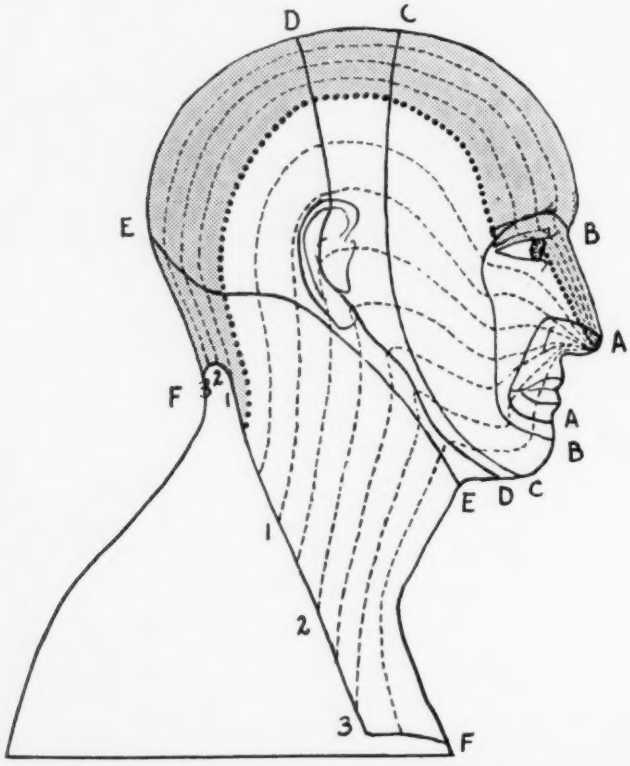

FIG. 6.—The direction lines of the head seen in profile.
This figure was drawn by establishing first the dorsoventral dividing line (dots) running from the tip of the nose in a wide curve down the neck in back of the ear. Then other lines were drawn.
A–A. The caudal limit of the first trigeminal segment (Dejerine[3]).
B–B. The caudal limit of the second trigeminal segment (Dejerine[3]).
C–C. The cephalic limit of the second cervical segment (Brouwer[6]).
D–D. The caudal limit of the trigeminal nerve (Brouwer[6]).
E–E. The caudal limit of the second cervical segment (Dejerine[3]).
F–F. The caudal limit of the third cervical segment (Dejerine[3]).
With these lines established, it was simple to divide the dorsal area first in half, then into quarters, and the ventral area in halves, then into quarters and finally into eighths, and to draw the dashed lines. Line 2 divides the dorsal and ventral areas in half. Lines 1 and 3 divide the halved areas into quarters. The dorsal area is shaded.

is partially ventral, rather than one which is neither dorsal nor ventral and lies, as did its lateral line ancestor, on the dorsoventral dividing line.

With this change in character of the eye and ear regions, there occurs a change in the distributions of skin nerves, which have as one of their functions the correlation of the several body parts which they supply. When

ventral structures are linked to dorsal (eye) or dorsoventral line (ear) structures, ventral nerves go to these areas. Several other factors may have contributed to this change, as will be pointed out later in this paper.

DIVISION OF THE CUTANEOUS DISTRIBUTION OF THE TRIGEMINAL NERVE INTO HEAD-END AND TAIL-END AREAS

The surface of the human body may be divided by a line which encircles the body at the umbilicus. All parts of the skin anterior to this line (think first of a four-footed animal and then of man as an erect quadruped) are head-end, all parts posterior are tail-end. In any particular region we may speak of more cephalic or more caudal areas. With this in mind, let us analyze the more headward or more tailward parts of the trigeminal area (see middle cut of Fig. 5).

The first thing which is seen is that the maxillary branch is headward of the mandibular. A is the anterior end of the dorsoventral dividing line.

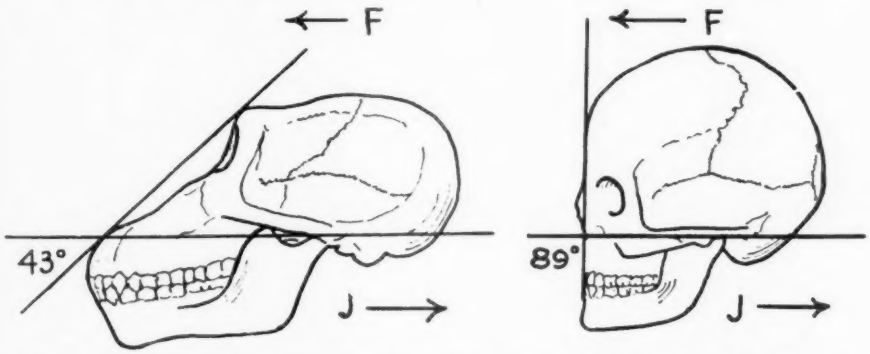

FIG. 7.—The changes in the facial angle to show the recession of the jaw and the protrusion of the forehead (after Lull,[7] modified). F—Forehead. J—Jaw.

The boundaries of the areas supplied by these nerves show a number of things. The areas and their boundaries should, for this analysis, be thought of as existing in a cephalo-caudal axis running along the line AD. The length of AC is much greater than AD. This emphasizes the frontal expansion of the skull. The line DA is much longer than AB, and the line FE is much longer than EB. This reëmphasizes the effect of skull expansion and of forward tilting of the head in spreading the region above the dorsoventral line. It also emphasizes the result in the ventral area of the absence of skull expansion and the presence of forward tilting of the head in contracting the area below the dorsoventral line.

The curves of the lower parts of the lines DB and FE emphasize the protrusion of the chin, just as the expansion of the frontal area is illustrated by a consideration of the relation of the line CA.

The line AC is much longer than the line AB. This emphasizes among other things the greater length of the dorsal trigeminal boundary line. AB is

divided into AE and EB, showing that the mandibular area, AEF, is caudal to the maxillary, EBDF. Further analyses from this chart may be made, but they would carry the length of this paper far beyond its permitted limits.

TILTING FORWARD OF THE HEAD AND THE GENERAL DIRECTION LINES ON ITS SURFACE

As man and the great apes acquired the erect posture, and the direction of the cephalo-caudal axis of the body changed from horizontal to vertical, a

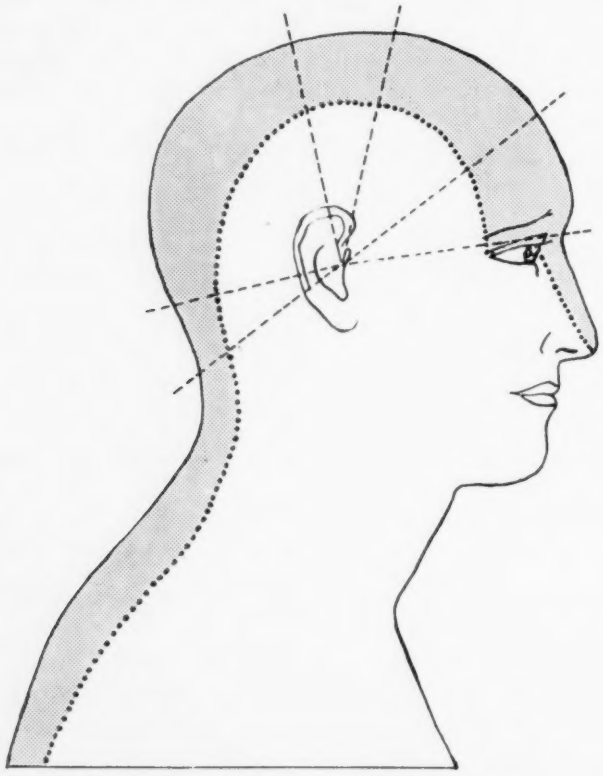

FIG. 8.—This emphasizes the fan-like expansion of the segments of the head. Some of the guide lines of Fig. 6 have been used to establish some of the dotted lines of this figure.

The two lines beginning on each side of the vertex of the head were located by the boundaries of the overlap between the trigeminal nerve and the second cervical segment. The two lines beginning at the front of the head were located by the boundaries between segments 1 and 2 and segments 3 and 4, respectively, of the trigeminal segmental distribution. These two lines were drawn to the back of the head. The dorsal area is shaded.

conflict took place because the old and fundamental forward pointing of the nose, for the head-end tip of the quadruped body had to be maintained. The compromise was the forward tilting of the head. Our nose still points forward. The direction lines of the head illustrate this (Fig. 6). Among other things, they also illustrate the effects of the expansion of the skull, the reces-

sion of the jaw (Fig. 7) and also the convergence to the head-end tip of the nose.

An analysis of what has happened when man's head became tilted forward shows that its segments have migrated and have opened out like a fan, the end of whose handle lies near the ear (Fig. 8). Another cause of this fan-like opening of head segments is the growth of the brain and the resulting expansion of the skull.

The direction of segment migration is toward the nose. Due to this, primitive location and primitive identity of form in segments is greatly changed. It is as if a force had pulled them upward on the neck, forward on the vertex and downward on the forehead and the nose. The amount of

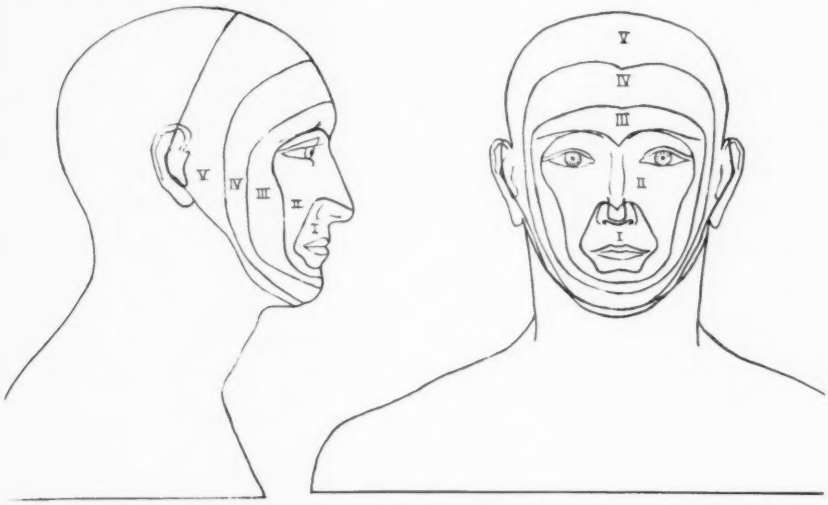

FIG. 9.—The segmental division of the trigeminal nerve area with the modification of the line separating Zones 2 and 3 which is discussed in the text (after Dejerine,[3] modified).

segment shift is greatest at the forward end of the body and fades as we go tailward.

A complete analysis of the migration, overlap, expansion, contraction and distortion of these head and neck segments would take many pages and would require an analysis of all body segments. This oversteps the scope and permitted length of this paper.

OBSERVATIONS ON DEJERINE'S CHARTS OF THE PERIPHERAL AND SEGMENTAL CUTANEOUS DISTRIBUTION OF THE TRIGEMINAL NERVE

There is a curious disjointedness of the parts of the dorsoventral line in Dejerine's[3] chart of peripheral trigeminal distribution (see his Fig. 376). This is seen where the dividing line between the ophthalmic and maxillary nerves ends and the dorsoventral cervical line begins. These lines are not continuous in Dejerine's chart. In view of what has been said above, it is

clear that these two separated ends should join to form a continuous line (Fig. 1).

If the profile view of the segmental lines of the trigeminal given by Dejerine (Fig. 9, see Dejerine's Fig. 378) are drawn on a plaster cast of a human head and then the cast is turned face front and a front view of these lines is drawn, it becomes apparent that a slight error has been made in that part of the dividing line between segments 2 and 3 runs upward from above the pupil to the forehead. This should point downward (Fig. 9).

We know that these dividing lines, mainly deduced from cases of syringobulbia and syringomyelia, are arbitrary in their exact location and only give a general idea of the way in which the central portions of the trigeminal are represented on the skin and the direction of the boundaries of segmental areas. We also know that during evolution there is a process of caudal stretching from the head-end nose tip of head segments due to progressive skull expansion and forward tilting of the head. These are not the only factors in determining the form of the skin areas of head and neck segments, but they will suffice to illustrate the slight error in Dejerine's Fig. 378. A study of Fig. 10 and a consideration of its legend further emphasizes this slight error.

FIG. 10.—The first two segments of the face are shown. The modification of the caudal outline of segment 2 (see Fig. 9 and text) is indicated here. It is well known that the eyebrows and forehead creases dip towards the tip of the nose. Furthermore, in monkeys and apes with hairy foreheads this general forward dip is easily seen not only by examining the hair distribution, but by the differences in hair color. The area of the two first segments resembles the face of monkeys and apes (Elliott[8]).

SUMMARY

The concepts of two basic divisions of the body, one dividing it into dorsal and ventral areas, the other dividing it segmentally along the cephalo-caudal axis, are the bases of a new analysis of the cutaneous trigeminal nerve distribution.

The trigeminal area has first been charted as divided into dorsal and ventral areas. These areas have then been analyzed from the viewpoint of the cephalo-caudal axis of the body. The well-known peripheral and segmental distributions have been the starting points for these analyses.

The influence of these new concepts upon our knowledge of the relation of disease in various structures, dorsal or ventral, of the head itself to types and locations of trigeminal neuralgia remains to be seen. Further studies with these concepts in mind will, it is hoped, aid in the understanding and treatment of this serious disease.

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THE TREATMENT OF CAUSALGIA BY THORACIC SYMPATHETIC GANGLIONECTOMY

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Causalgia as a clinical entity has been known since the days of 1864 when Weir Mitchell, Moorehouse and Keen first described this syndrome as they observed it among soldiers wounded in the Civil War. Their original description has not been surpassed by modern writers.

Occurring after injury, causalgia is characterized by a severe, constant, burning pain in the region supplied by one or more of the major nerves to an extremity. The nerves most frequently involved are the median of the upper and the sciatic of the lower extremity. Although the entire limb may be affected, the pain is limited frequently to the palm and fingers of the hand and the sole and toes of the foot.

The extremity thus involved usually presents evidences of trophic changes. There is invariably cyanosis of the hand or the foot which is moist or clammy. Less often it may be dry and warm. The skin is thin and stretched tightly over the digits and has a glossy appearance. While this shiny and glossy skin is found as a rule, it does not invariably occur. Pollock and Davis[1] state that in the World War many cases of painful syndrome resembling typical causalgia lacked nothing but the glossy skin. The threshold of the general sensorium of a patient suffering from causalgia is lowered greatly and any external stimulus although trifling in itself usually exaggerates the pain. Excessive movement or jarring of the body is tolerated badly. The victim protects the affected limb and seeks a secluded spot.

The nature of causalgia is still imperfectly understood. Although it may appear spontaneously, rarely does it develop without a history of previous trauma. It is associated more frequently with partial division than with complete interruption of the continuity of a nerve. Nor does the pain always make its presence known immediately after an injury; days, weeks and months may elapse before the symptoms appear. Spurling[2] speaks of causalgia as synonymous with ischæmic pain. It is true that inadequate circulation in the extremity is a finding frequently associated with causalgia and that the pain experienced by patients suffering from thrombo-angiitis obliterans or other peripheral vascular occlusions often simulates it closely. Pollock and Davis[1] do not consider concomitant lesions of the blood-vessels a constant factor in the production of causalgia.

The origin of causalgic pain in some disturbance of the sympathetic nervous system in the diseased limb is now accepted widely although Diez[3] is unwilling to make this concession. That the sympathetic nerve fibres do

carry impulses of pain is a well-established fact. The presence of more non-myelinated nerve fibres in the median and sciatic nerve trunks than in other large peripheral nerves also has been shown. The fact that these two nerves are involved most frequently in causalgia is at least suggestive. Leriche raised the question whether neuritis of the peri-arterial sympathetic plexus is not responsible for the pain.

Following the lead of Leriche, peri-arterial sympathectomy has been used more frequently than any other single method for the relief of causalgia. The method, however, has not been successful in my hands. It may be largely due to the fact that the distribution of the sympathetic fibres to an artery is really a segmental one and that the removal of a portion of the adventitia of the brachial artery, for example, will not prevent the sympathetic fibres from reaching the peripheral portions of the vessel by way of the more distal divisions of the nerves. Sheehan is of this opinion.[4] In order to interrupt effectively the sympathetic outflow to an extremity, sympathetic ganglionectomy or complete ramisectomy must be carried out.

The case reported in this paper is of interest inasmuch as extensive neurolysis of the brachial plexus, peri-arterial sympathectomy of the brachial artery and excision of a segment of the axillary artery all failed to terminate the causalgia, while thoracic sympathetic ganglionectomy gave prompt relief.

CASE REPORT.—September 29, 1931, W. C. E. entered the Peiping Union Medical College Hospital on account of severe shooting pain in the left hand and forearm, which had been present for forty days. The patient was twenty-seven years old and a soldier by profession. July 1, 1931, he was shot in the region of the left clavicle which was shattered in its mid-portion. The bullet was retained and later was found to be imbedded in the soft tissues between the left scapula and the chest-wall. The gunshot wound healed without infection in approximately two weeks. There had been immediate loss of the motor function of the left upper extremity at the time of injury, but this gradually improved until at the time of admission the paralysis was only partial.

Six weeks after the gunshot wound had been sustained, shooting pain in the left hand began. It was intermittent at first, occurring about ten times a day, but gradually the interval shortened and the pain became more severe. The patient described the pain by saying that it felt as if "the blood could not pass to his hand." It was burning in character and for this reason he always exposed his arm and chest to the cold air. Every heart beat, every motion of the arm and every noise in the room intensified the pain. He could not tolerate bright lights and preferred to lie quietly in bed with his eyes closed. In the few days preceding admission the pain in the forearm and the hand had become constant. It was with difficulty that the patient could be persuaded to move or eat.

Examination revealed the following pertinent findings. He was an emaciated young man evidently in great distress. He kept his eyes closed and talked only in a low voice. His left hand was held across the abdomen supported by the right. (Figs. 1 and 2.) The left elbow was flexed at 120°. There was marked tenderness on pressure below the level of the elbow joint. The skin from there down was warm, red, smooth, and shining. Frequently, however, drops of perspiration could be found on the forearm and palm. All movements of the upper extremity were possible but they were considerably restricted in every direction, especially pronation of the forearm and flexion of the wrist. The thenar and hypothenar eminences were flattened and the interosseous muscles were atrophic. The fingers were more or less claw-shaped. There

was hypesthesia involving chiefly the areas supplied by the musculocutaneous and the antibrachial cutaneous nerves. The pulsations of the left brachial, ulnar and radial arteries were very feeble as compared to those of the opposite side.

Laboratory examinations showed normal findings in the blood and urine. Röntgenological examination revealed a healed fracture of the mid-portion of the left clavicle and a foreign body retained in the tissues between the left scapula and the chest-wall.

There was no doubt that the patient was suffering from causalgia due to a traumatic injury to the brachial plexus resulting in either a complete division of a part of the fibres or an extensive fibrosis of the nerves. Furthermore, there was evidence that the axillary artery was occluded either totally or in part. In view of the findings it seemed wise to explore the wound.

First Operation.—October 5, 1931. Partial ostectomy of the clavicle; removal of

FIG. 1.—Shows the characteristic attitude and facial expression which the patient assumed constantly before sympathetic ganglionectomy.

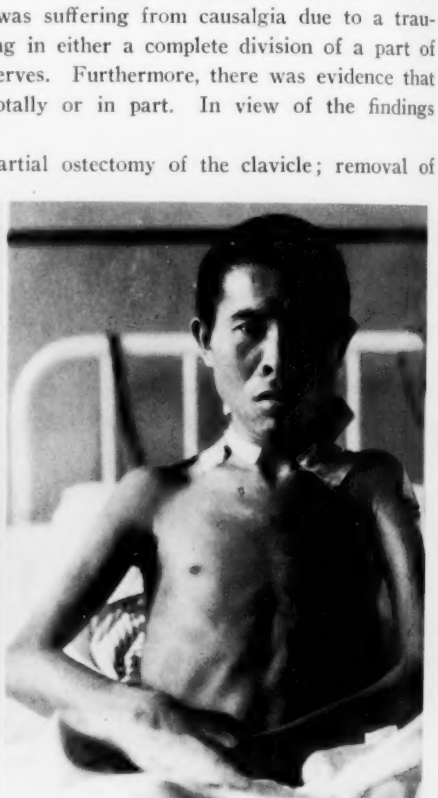

FIG. 2.—Unposed photograph of the same patient four days after sympathetic ganglionectomy. Note the narrow palpebral fissure on the left side.

callus; neurolysis of the brachial plexus. Colonic ether anæsthesia. An incision was made starting from the middle of the posterior border of the sternocleidomastoid muscle, extending downward below the clavicle and then curving outward to the acromion process. The clavicle was thus exposed and that portion which was in malunion was removed together with the excessive callus which was pressing on the brachial plexus directly. It was noted that that portion of the plexus lying beneath the callus was enveloped by dense fibrous tissue and that the periosteum of the clavicle was intimately adherent to it. Effort was then made to free the brachial plexus from these adhesions, but before this could be completed satisfactorily the pulse rate of the patient became so rapid that it was necessary to terminate the operation.

Recovery from the operation was prompt, but the next day the patient complained of pain which was even more severe than that which he had experienced previously. The pain was localized chiefly in the anterior surface of the wrist and the

palm of the hand. Several weeks later a second attempt to relieve the symptoms was carried out.

Second Operation.—November 10, 1931. Peri-arterial sympathectomy of the brachial artery; injection of median nerve with alcohol. Ether anæsthesia. A longitudinal incision was made over the course of the brachial vessels at the point where they emerge from the axilla. The neurovascular bundle was isolated and opened. All the structures within the sheath appeared normal. The brachial artery was of usual size but pulsated very feebly. The adventitia of this vessel for a distance of approximately two inches was stripped away. Four minims of 60 per cent. alcohol were injected beneath the sheath of the median nerve at several points in its circumference. The wound was closed with interrupted sutures of fine silk. This operation was equally devoid of benefit to the patient.

Third Operation.—November 24, 1931. Extensive neurolysis of brachial plexus; resection of the axillary artery. Brachial block and local novocaine infiltration anæsthesia. Two weeks after the second operation, the brachial plexus was reëxplored. A long incision which included the original one gave perfect access to the plexus. The median, ulnar, musculocutaneous and radial nerves were individually isolated and identified, as was the axillary artery. At the point where the lateral and median heads of the median nerve unite scar tissue was encountered. From here upward beneath the clavicle the entire brachial plexus as well as the axillary and subclavian vessels were involved in a firm dense mass of fibrous tissue. This mass was isolated on all sides and eventually after prolonged dissection it was possible to follow the axillary artery through it. The lumen was completely obliterated and the artery was reduced to a mere fibrous cord. It was divided just proximal to this point of obliteration and three inches of the artery were resected distally. Further effort was then directed toward relieving the adhesions about the various cords of the brachial plexus. They were divided on all sides but it was impossible to disentangle completely the mass of scar tissue and nerves which involved the entire plexus at the level of the clavicle. At the completion of the operation fine linear incisions were made along the line of the nerves in the hope that the internal pressure on the nerve bundles might be relieved. The cords were further injected with normal saline solution in order to distend the nerve sheaths, and the wound was closed. The patient continued to have the same severe shooting pain in the left hand that he had had before the operation.

Fourth Operation.—December 14, 1931. Thoracic sympathetic ganglionectomy. Colonic ether anæsthesia. This operation was performed five and a half months after the patient had been injured. The approach to the left upper thoracic ganglia was made through a posterior mediastinotomy, as recommended by Adson. The first rib was isolated and its muscular attachments including those on the transverse process of the first thoracic vertebra were cleared away. With a chisel this transverse process was broken off close to the body of the vertebra. The first rib was then rongeured away from a point half an inch beyond the neck down to and including the head of the rib. With the bone removed the second thoracic nerve came into view, and was used as a guide to the sympathetic chain. The trunk of the latter structure was lifted by a hook and made taut. By this procedure the individual rami communicantes joining the second thoracic nerve were identified easily and severed. The main trunk was then divided just below the ganglionic enlargement. The proximal end of the divided sympathetic trunk was seized with a clamp and the rami to the first thoracic nerve were divided. By pulling the sympathetic trunk downward the inferior cervical ganglion, which in this instance was very small, was brought into view and the sympathetic trunk was cut just above this level. The wound was closed with interrupted sutures of medium silk. (Fig. 3.)

Examination on the day after the ganglionectomy revealed a different patient. The constant severe shooting pain was relieved completely. In its place, however, there was a certain feeling of distention in the left arm. The left eye showed a small pupil, narrow palpebral fissure and enophthalmos. The left side of the face and the left

upper extremity were drier and warmer than those of the right side. The patient could now tolerate manipulation of the left arm without pain. He was discharged December 29, 1931.

Three months later the patient was re-admitted for examination and for correction of a contracture of the fingers of the left hand. The causalgic pain had been relieved entirely. The "distention pain" was still present, especially when the arm was placed in a dependent position.

COMMENT.—The exact relationship between the vegetative and cerebrospinal nervous systems in the conduction of painful sensation has not been clearly understood. Dragonesco and Kreindler,[5] in a lengthy review of this subject, brought out the fact that the vegetative system not only receives and conducts impulses from the skin but that it also modifies the excitability of the extrasympathetic nerves. They further state that Foerster and

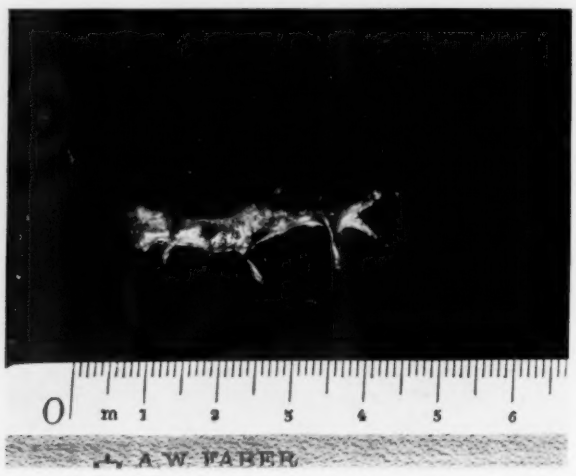

FIG. 3.—Portion of the left cervicodorsal sympathetic chain removed at operation.

his co-workers are able to show that the chronaxy of painful and tactile points on the skin is diminished by section of the sympathetic nerves to that area. Whether this regulation by the vegetative system of the threshold of the perception of sensory stimuli is effected through a change of ion concentration or by the action of a local hormone it is difficult to say. It is interesting to note that Gaza and Brandi[6] have demonstrated a relationship between the concentration of H ions in the tissues and the sensation of pain; and that alkalinization of the tissues abolishes pain. Dragonesco and Kreindler conclude that causalgia is an expression of a sensory hypertony. They believe that the ionic and hormonic grouping is such in causalgia that the excitability of the cerebrospinal pathway is very much increased. Just as there is an increase in muscle tonus in the rigidity of pallidal disease, so also there may be a sensory hypertony brought about by an increase of the excitability of the vegetative system.

In the treatment of causalgia many different procedures have been sug-

gested. Neurolysis, which appears to be the most logical procedure, is often the least productive of relief. Section of the involved nerve trunk, division of the dorsal root or chordotomy have been recommended.[7] While effective they entail what seems to be a needless sacrifice of sensation or motor power or both, and needless to say only in the most persistent cases ought they to be employed. Sympathetic ganglionectomy seems to offer the best promise of a satisfactory result, and it succeeds where peri-arterial sympathectomy fails.

The case reported here is almost a duplicate of that of Spurling. Division of the brachial plexus would have given relief from pain because injection of the brachial plexus with a solution of novocaine produced relief as long as the anæsthesia lasted. But this procedure would have rendered the arm useless. Division of the dorsal roots of the involved nerves would have abolished or diminished widely sensation in the arm, while chordotomy would have resulted in anæsthesia of the left side of the trunk and left lower extremity as well. Removal of the sympathetic ganglia, on the other hand, relieved the pain without creating any gross functional disability. For this reason it is believed that cervicothoracic sympathetic ganglionectomy may prove a valuable procedure for cases of causalgia of the upper extremity. In a recent case of causalgia resulting from a gunshot wound of the median nerve just above the elbow the pain was promptly relieved by an injection of the first and second dorsal sympathetic ganglia. This did not produce any diminution of sensation or power in the distribution of the brachial plexus.

SUMMARY

(1) Causalgia is a painful condition chiefly of sympathetic origin.

(2) A case of causalgia of the upper extremity treated by neurolysis of the brachial plexus, peri-arterial sympathectomy of the brachial artery and resection of the axillary artery continued to suffer from pain. Cervicothoracic sympathetic ganglionectomy gave prompt relief.

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THE SELECTION OF PITUITARY CASES FOR SURGERY

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During the past few years there has been considerable difference of opinion as to the respective merits of surgery and Röntgen therapy in the treatment of pituitary tumors. It is now almost universally recognized, as a survey of the literature pertaining to the subject shows, that there are two real indications for surgery in the treatment of pituitary tumors: (1) visual failure of greater or less degree, and (2) intractable and severe headaches. There are many patients not only of the acromegalic or gigantic type, but also of the Fröhlich syndrome, in whom operation is not indicated regardless of the prominence of the clinical syndrome, the presence of a definitely enlarged sella turcica or marked variations in metabolic rate. Such cases fall within the province of the endocrinologist rather than the neurosurgeon.

In reviewing the literature on the subject, Cushing[1] stated, as far back as 1912, that "in certain forms of hypophyseal tumor, prolonged röntgenization has a notable effect in ameliorating the neighborhood symptoms, due in all likelihood, to a definite shrinking of the growth. A widening of the constricted fields of vision serves as a reliable index of any diminution in the size of the struma. It would appear that neoplastic cells of epithelial type are particularly prone to undergo atrophy without inflammatory reaction under prolonged radiation. It is possible that radiotherapy should often be employed as a supplementary measure."

It is now a common procedure to use Röntgen therapy after operation as a supposed aid in preventing further hyperplasia of the gland. Whether or not this is a rational procedure would depend entirely upon proof that pituitary adenomata are indeed influenced by the Röntgen-ray. Cushing[1] quotes two cases in which pressure symptoms remained marked despite the partial emptying of the sella, so marked indeed that subtemporal decompression was later performed and subsequent radiotherapy led to an evident diminution of all the tension phenomena. One of these cases on histological examination had a chromophobe struma and the other was diagnosed clinically as dyspituitarism and was characterized by a large struma with intracranial extension.

It must be remembered, however, that much has been learned about pituitary adenomata since this book was written, and the same author has said recently (1932),[2] after a much wider experience, that it is doubtful whether Röntgen-ray treatment has any effect whatever upon the chromophobe adenomata.

Dott and Bailey[3] described two cases in which temporary aggravation of the patient's symptoms was observed after Röntgen therapy. Sudden and severe headaches followed the treatments. The patients suffered from in-

creased difficulty of vision and from general lassitude and prostration. One of these was subsequently completely relieved by a sellar decompression. Such temporary aggravation of symptoms is due, presumably, to acute degenerative processes, accompanied by swelling of the tumor tissue. The authors advocate a trial of Röntgen-ray therapy (without designation as to histological type) unless there is imminent danger of loss of vision, when a sellar decompression should be done forthwith. During the course of treatment the progress of events should be carefully controlled by repeated perimetric examination.

Frazier,[4] in discussing the subject, believed that the main problem lay in trying to determine under what circumstances one is warranted in employing the effects of irradiation before operation. In weighing the problem, one must consider not so much the field distortions as the appearance of the disks.

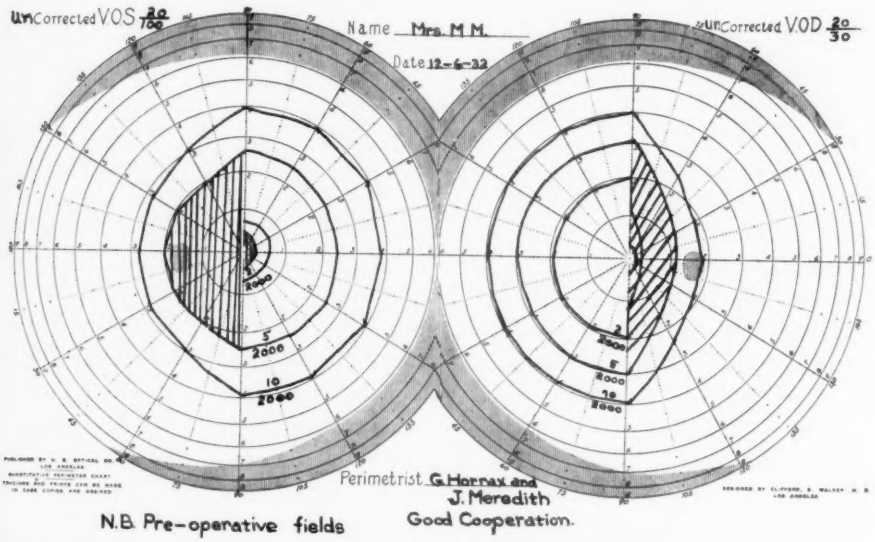

FIG. 1.—Pre-operative visual fields. Note the reduced acuity in oculus sinister with loss of central vision. There is, in addition, moderate bitemporal hemianopsia.

If the signs of atrophy are not too far advanced and if, with repeated examination, the capillarity of the disks remains more or less unchanged, one can with propriety, postpone operation. If vision be well preserved, as in the case he reported, Röntgen-ray therapy may be tried. However, if the patient be already blind in one eye and vision is rapidly failing in the other, as is often the case when the patient is first seen, procrastination is never justified. Irradiation will have no influence on a lesion already cystic. Frazier[4] stated that he knew of only one case in his experience in which the beneficial effects of irradiation had been sustained. In a few other cases, there was improvement at first, but relapse later. His one successful case showed no signs of relapse in vision three and one-half years after treatment was begun.

In 1926, Towne[5] reported his experience with a patient who had an intracranial extension of a pituitary adenoma. Visual examination showed a loss

of central vision on the left with an acuity of 15/70. Röntgen-ray therapy was begun because of the patient's poor condition. After treatment, the acuity was 20/30. Two and one-half years later, the visual fields were normal and there was 15/20 acuity in each eye. A second patient, with an intracranial extension of a pituitary adenoma, was subjected to the same treatment with no recurrence after two years. According to Towne, twenty per cent. of pituitary adenomata are cystic. If an adenoma is not favorably influenced by the Röntgen-ray treatment, one may suspect cystic degeneration which calls for surgical intervention. He concludes by stating that all adenomata of the pituitary gland should be treated with moderate doses of Röntgen-ray therapy and progress should be followed by repeated perimetric examination. It is his opinion that when Röntgen-ray treatment gives a favorable result, the risk is less and the result more lasting than that of surgical treatment.

Another paper by the same author[6] states that twenty per cent. of Cushing's pituitary cases conserved useful vision for more than five years postoperatively, but it apparently is not known whether the ones which have useful vision after that length of time were the ones with cystic tumors or not. If this were so, there should be, then, good results in 80 per cent. of the irradiated cases as this number would be non-cystic in character and hence more radiosensitive. Towne stresses the careful selection of cases; only adenomata which enlarge and destroy the sella are amenable to Röntgen-ray therapy. A satisfactory method is to insist that the patient report for perimetric examination before each treatment.

In this same paper, Towne reports the end-results in three patients who had been subjected to Röntgen-ray therapy first and later on had been operated upon. The first case showed restoration to normal visual acuity and fields for five years after Röntgen-ray treatment. The tumor then recurred. Röntgen-ray therapy failed and there was temporary improvement after operation with death seventeen months later, following recurrence of the tumor. The second case showed restoration to normal vision and fields following treatment. Two years and eight months later, the tumor recurred. Röntgen-ray treatment failed. There was improvement after surgical evacuation of the cyst which lasted up to the date of the report, three years after operation. The third case had been blind for three months and showed slight visual improvement after irradiation. There was no visual improvement following subsequent surgery, the optic atrophy being already too far advanced. The lesson to be learned from the report of these cases is that it is unwise to procrastinate too long in employing surgery until optic atrophy has advanced so far as not to be benefited by operation. It is also apparent, from the second case, that irradiation in cystic adenomata is useless. Stress should be placed on the fact that if such therapy does not almost immediately improve vision, the lesion is probably cystic, especially if of the "chromophobe" type, and operation should be performed without delay.

Dyke and Gross[7] report five cases of pituitary tumor in which Röntgen-

ray therapy was used. In every case, headache was entirely relieved and in three there was improvement in vision; the remaining two showed no further loss of vision. One of these, clinically, was a chromophile adenoma. They quote another case which improved only temporarily with Röntgen-ray therapy and was found at operation to have a cystic adenoma. Elsberg is quoted by them as believing that every patient with visual field defects due to a pituitary adenoma should first receive deep irradiation. He uses it, then, as a diagnostic test, separating, thereby, in a large measure, the cystic from the solid

FIG. 2.—X-ray of sella. The sella measurements are 16x19; normal 12x15. Note the very delicate perpendicular dorsum sellæ.

tumors, utilizing the response to Röntgen-ray therapy as the criterion of diagnosis.

Beclere[8] concludes that "when there is the least suspicion of a tumor in the hypophyseal region it is necessary to resort to Röntgen-ray therapy which must always be tried and that only in case of failure therefrom is one justified in resorting to surgery." He also states that in the medical treatment of hypophyseal tumors, especially of gigantism and acromegaly, well directed irradiation constitutes the best means we possess and is the more effective the sooner it is employed.

Gramegna[9] simply states that it is permissible to think that Röntgen-ray therapy applied to recent cases even when the phenomena of compression do not yet exist, and repeated if necessary, with those patients held under observation for a long time, should be able to stop, for a considerable length of time, the evolution of the disease.

Bailey[10] reports the case of an acromegalic who suffered headache and nausea twenty-four hours after treatment by irradiation. Still another patient had severe headache with vomiting and marked diminution of vision following Röntgen-ray therapy. These symptoms suddenly ceased and a subsequent operation showed that the tumor had decompressed itself by rupturing into the sphenoid sinus. He recommends that irradiation treatment should be tried if the patient is not in imminent danger of losing his eyesight, but this is a difficult question to decide in the light of the experience just quoted. At all events, the visual fields should be followed carefully and the patient operated upon if vision continues to fail. Certainly, after operation, continued treatment should be given.

Froment[11] recommends the use of X-ray in the treatment of adenomata associated with Fröhlich's syndrome, stating that in some cases the symptoms recede to a marked degree. In one case, the clinical remission lasted for six years after Röntgen therapy; concluding that one should be able to stay one's hand before irremediable damage is produced.

Hare and Dyke[12] emphasize an important point when they state that the first effects of irradiation are probably a temporary swelling of the neoplasm and œdema of the contiguous brain tissue. These changes are manifested by a decrease in visual acuity and the visual fields within twenty-four to forty-eight hours, and occasionally by vomiting, headache and vertigo. At this time, intravenous injection of an hypertonic solution of glucose may be useful to prevent severe œdema. These authors also wisely insist that the patients should be hospitalized during the first series of treatments so as to receive the benefits of dehydration therapy or operation without delay, should it be indicated. In commenting on the effects of Röntgen therapy in pituitary cases, they state that in a series of twenty cases of their own, headache and drowsiness were partially or completely relieved in 75 per cent. of patients. Menstrual disturbances and diminution of libido in the male were often favorably influenced by Röntgen therapy.

On the other hand, improvement in vision occurred in only 25 per cent., due, as the authors point out, to the fact that endocrine symptoms can still be influenced by irradiation when irreparable damage to the optic nerve fibres has made improvement in vision impossible. This is the crux of the situation. It is agreed by all that vision is by far the most important function to save in patients with enlarging pituitary adenomata and if only one in four is benefited in this latter respect, the efficacy of the therapeutic method is seriously impugned.

Turning now to the operative side of therapy, one may quote Cushing whose operative mortality for chromophobe adenomata is 3.8 per cent.; for

chromophile lesions 10 per cent. In Cushing's operative series,[13] 21 per cent. of the cases had restoration of fields and acuity to normal after operation by the transfrontal route; an additional 42 per cent. showed considerable or marked improvement. With irradiation Hare and Dyke had only 5 per cent. return of vision to normal, an additional 25 per cent. showed improvement in vision and 25 per cent. showed further diminution in vision after Röntgen therapy. Thus it can be seen, in these series of patients, that operation is over

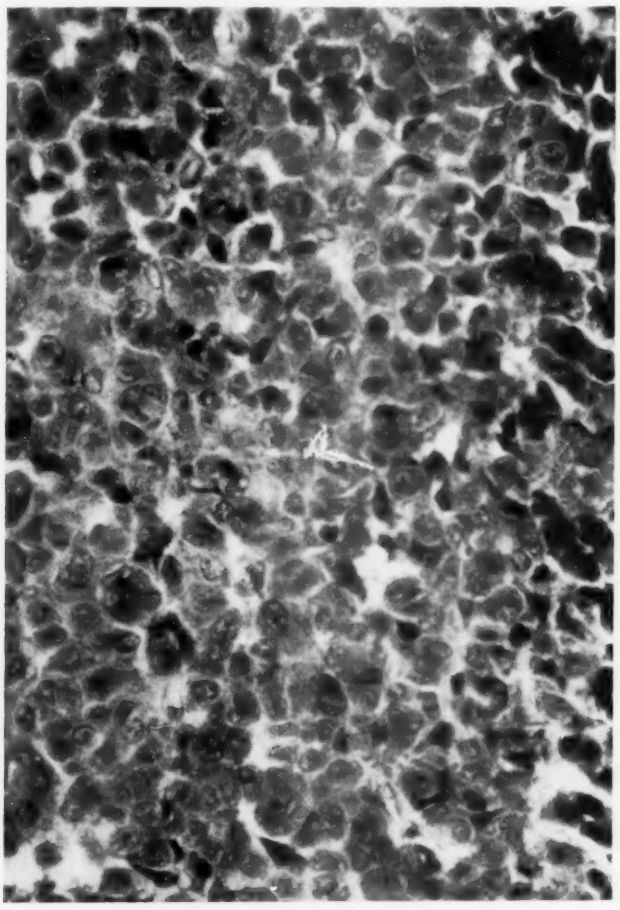

FIG. 3.—Photograph of tissue removed at operation (6x15). The appearance is typical of the chromophile adenomata found in patients with acromegaly.

twice as effective as irradiation in restoring vision to normal or at least improving it considerably.

Hare and Dyke believe that patients with normal fields and visual acuity, with a positive diagnosis of a pituitary tumor based on marked sellar enlargement and definite acromegaly, should be subjected to irradiation although this is not so true if vision has begun to fail. They state that the best

Röntgen-ray results occur in early cases of visual failure and they believe that in the large majority of cases, Röntgen-ray treatment should be tried before surgery.

In a review of the authors quoted, it is seen that there is by no means a unanimity of opinion on this important subject, which perhaps makes for healthy progress but does not serve to clarify the issue.

Although almost all authors agree that chromophile, non-cystic adenomata are helped, to a greater or less degree, by irradiation, more than are the chromophobe types, the case now to be described is an example of the chromophile type which was not aided by prolonged Röntgen therapy but was greatly benefited by subsequent operation.

CASE I.—An acromegalic who, after forty irradiation treatments, showed 20/100 vision in oculus sinister with loss of central vision. Operation disclosed a chromophile adenoma. Sixteen days later, acuity in oculus sinister was 20/30; headaches had disappeared.

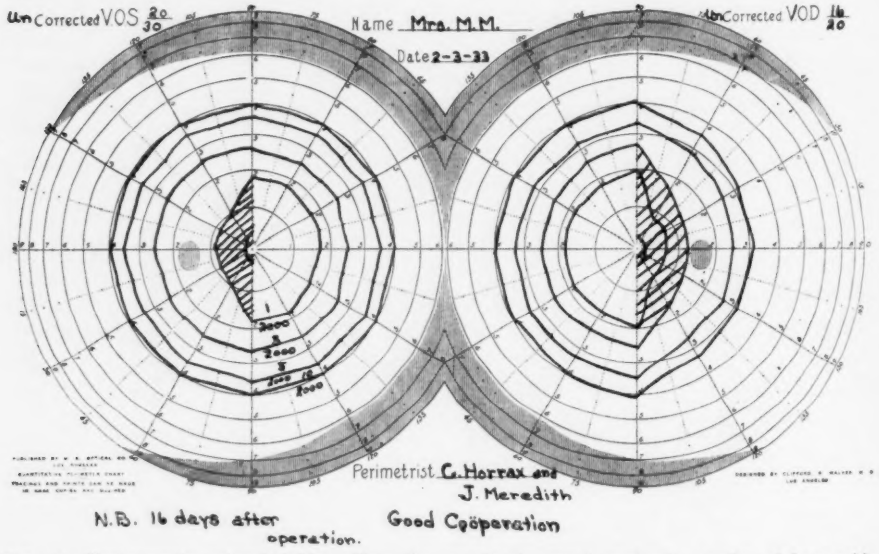

FIG. 4.—Post-operative visual fields. Note the greatly improved acuity in oculus sinister with satisfactory widening of the temporal fields, peripherally.

Mrs. M. M., aged thirty-one, housewife, was referred by Dr. H. J. Spencer of New York City. She was first seen at the Clinic December 2, 1932, complaining of "brain tumor." Six years before this, menstruation had ceased. Headaches began about the same time. Her features had been getting larger and coarser in the last two years. Two years previously irradiation treatments were begun, forty treatments in all having been given, in another city. She had been married twelve years and had had two pregnancies with one miscarriage.

Examination disclosed a white, adult woman with coarse features, obviously acromegalic. Old photographs of the patient showed facial changes. She had spade-like hands and large feet. Blood-pressure 133/80. Vision was greatly reduced subjectively, particularly in the left eye. Objectively she showed 20/30 acuity on the right and 20/100 on the left. Bilateral primary optic atrophy was present. Perimetric charts showed greatly contracted temporal fields with paracentral partial scotomata which involved the macula in oculus sinister (Fig. 1).

X-ray of the skull (Fig. 2) showed a greatly enlarged sella turcica, measuring sixteen millimetres in depth by nineteen millimetres in transverse diameter. The dorsum sellæ was represented only by a very delicate perpendicular line. Two basal metabolic determinations were +16 and +18. The blood cholesterol, on two occasions, was 153 milligrams and 145 milligrams. (We have been estimating the blood cholesterol on all our pituitary cases and find that there is little variation in the patients regardless of whether they are of the chromophobe or chromophile type. The highest value obtained was 243 milligrams in a chromophobe with metabolic rates of minus twenty-one and minus twenty-nine; the lowest value was 110 milligrams in a mixed type histologically but clinically decidedly of the Fröhlich's syndrome category with a metabolism of minus eighteen.)

The patient was then, a case of pronounced acromegaly, with serious visual impairment. She had been subjected to a prolonged series of Röntgen-ray treatments without relief. Her other signs and symptoms included amenorrhœa, headache, bilateral optic atrophy, bitemporal hemianopia and a greatly enlarged sella turcica.

FIG. 5.—Operative scar seventeen days after operation, demonstrating how well these wounds heal. In a year's time, it will be practically invisible.

The patient was discharged, returning on January 16, 1933. Operation was performed by Dr. Gilbert Horrax on January 18, 1933. The usual transfrontal bone flap exposure was carried out under local anæsthesia. Below and medial to the right optic nerve could be seen the grayish bulging capsule of the adenoma. The right optic nerve was considerably flattened and would soon have been compressed sufficiently so that vision in this eye would have been greatly impaired. The capsule was incised widely and a few scoopfuls of the tumor were removed. The tumor was then attacked with a sucker and a large amount of the growth thus removed. There were a few slightly cystic spaces, but the vast bulk of the tumor was solid. The left optic nerve was at no time seen but after a fairly extensive removal of the growth the capsule could be seen to be quite collapsed. The histological diagnosis was "chromophile adenoma" (Fig. 3).

The patient's convalescence was uneventful. On the third post-operative day she could read fine print with the left eye and was allowed up on the eighth post-operative day. Visual fields taken sixteen days after operation (Fig. 4) showed great widening of the peripheral (temporal) fields and a most gratifying result was the improvement in the acuity of the left eye which was now 20/30, having been 20/100 before operation. The accompanying photograph (Fig. 5) taken seventeen days after operation shows the well-healed wound. The patient was discharged nineteen days after operation, feeling quite well, free from headaches and vision greatly improved subjectively and objectively.

A letter from the referring physician, dated November 28, 1933, stated that the patient is now looking and feeling very well. The visual acuity in both eyes is 16/20-2, and form fields were full with the 2½ millimetre disk (white) at a distance of 1000 millimetres, with slight enlargement of the blind spot in O. S.

SUMMARY AND CONCLUSIONS

1. As amply demonstrated by a review of the literature, there is a great diversity of opinion concerning the indications for operation in adenomata

of the pituitary gland. There exists a diversity of opinion as to when to employ irradiation and when surgery.

2. It seems wise to limit Röntgen-ray therapy to cases with little or no visual impairment, with headache only, or with endocrine symptoms and no visual involvement.

3. Any and all cases subjected to irradiation before or in lieu of operation, should be temporarily hospitalized, and not treated as ambulatory patients, so as to combat any acute catastrophe caused by the treatment and necessitating immediate operation to conserve vision and even life.

4. The case here reported demonstrates that, although it is the consensus of opinion that the chromophile adenomata are more susceptible to irradiation than are the chromophobe types, this is not always true; furthermore, that an excellent result may be obtained by operation after the failure of prolonged irradiation.

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CHRONIC GENERALIZED FIBROMYOSITIS

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Case Report.—In September, 1932, a white male, forty-two years old with a "poker-spine" was examined. He exhibited a symptom-complex consisting of difficulty in walking on account of stiffness of the lower limbs, back and abdomen; severe spasmodic contractions of the back and abdomen; drenching sweats; tachycardia; tachypnœa; progressive loss of weight and "hardness" of the abdominal, spinal and thigh muscles, and myotonic manifestations.

History of Present Illness.—The earliest symptoms of the present condition were observed in September, 1931, when, on two or three occasions, a sudden momentary stiffening of the back and thighs occurred when attempting to get up from a chair. There was no stiffness or difficulty in walking after he started, the attacks apparently being associated with rising and turning suddenly. In November, he had a severe head and throat cold associated with severe pain in the lumbosacral region. He remained in bed only three days and had no untoward after-effects. Toward the end of January, 1932, he began to experience difficulty in getting up from an easy chair on account of stiffness of the back, and occasional difficulty in walking due to stiffening of the leg muscles. This stiffness recurred with increasing frequency and in February, a physician noted that the back was rigid and the patient able to bend only "as a unit." Stiffness of the legs came on frequently when he saw an acquaintance approaching. The patient refers to this symptom as a form of "stage fright" and says that it has been a distinct feature of his condition, so that he came to fear the possibility of meeting friends while out walking. The back had become more arched than normal, and the right hip and thigh stiffer. There was no pain as a rule except for a dull ache which occurred with the stiffness and rigidity of the muscles. Although this took place usually in the right leg, occasionally it occurred in the left without affecting the right.

His condition gradually grew worse until it became impossible for him to get out of a chair without experiencing the attacks of stiffening of the back and lower limbs. It would take a few minutes to limber up after which he would walk quite freely, although there was constant stiffness and a "drag on the back." Sleep was not much disturbed, although it was impossible to turn over in bed without using his arms and feet to pull and push the body over. Diathermy, ultra-violet light, and infra-red ray therapy gave nothing more than slight temporary improvement. In damp weather he had a moderate degree of stabbing pain in the right hip joint and lower back. In April, a body brace gave him a little comfort, but no relief from the muscle spasm nor any improvement in his general condition. Tenseness of the abdominal muscles with frequent spasmodic contractions occurred while lying on his back, and occasionally when sitting in a chair, but rarely when standing or walking. These contractions of the abdominal muscles would cause the body to flex sharply, bringing the feet and head up from the bed simultaneously. Because of this, he has been unable to lie flat on his back for more than very short periods. Almost from the very beginning, he perspired excessively on every occasion calling for more than an ordinary emotional response. It became worse as time went on and reached a maximum point while being studied in the University Hospital in September, 1932. Toward the end of May, 1932, there was a noticeable shortness of breath and a break in his voice when engaged in conversation. He continued to attend to his office duties, but was largely confined to his desk. About this time he noticed that the bowel movements had been ribbon-like in shape for a number of weeks, but a fluoroscopical examination of the intestinal tract

revealed no gross abnormality. In June, he was put to bed on fracture boards for three weeks with daily infra-red ray treatments to the back and a roll placed under the small of the back. He returned to the office after four weeks and noticed that there was some improvement which he attributed to the rest. There was more freedom of movement of the legs and less muscle spasm. After a few weeks it became evident that the condition was again returning to its former state and undoubtedly progressing. Another feature became noticeable about this time in the form of extreme jumpiness with a feeling of being "keyed up" all the time, so that any sudden noise or unexpected incident, such as the ringing of a telephone bell, or the breaking of the pencil point when writing, would cause a sudden jarring of the entire body. Search was made for foci of infection and a devitalized tooth was removed and found to have apical infection. X-ray examination of the teeth two months later revealed no residual focal infection. In January, 1932, his weight was 195 lbs., on September 4, 1932, it was 168 lbs. and on the 24th, it was 155 lbs.

At the hospital in September, 1932, the patient had to have a small pillow under the knees or back to relieve the abdominal and spinal spasms, and he was unable to bend over to put on his shoes. In order to pick up an article from the floor he had to squat. Crossing of the knees was impossible, particularly the right over the left; stiffness of the neck had appeared lately so that he could not bend his head as freely as before or move it fully to the right or left. He could not use a free throwing motion because of stiffness in the arm and shoulder. He had become more irritable and more easily upset, and when in this condition, or angry, he would stiffen or "freeze up" all over and be unable to make any voluntary movement. He added that any emergency calling for quick action would have the same result. He could not get up from the supine position except with great difficulty and then only when aided by getting hold of some fixed object and pulling himself up. There was no reference to difficulty with the hands or feet. He stated that perspiration was quite free all over the body but more profuse on the head, face, chest and back. He recently experienced an involuntary spasmodic retraction and jerking of the right arm while in the act of raising a glass of water to his lips. Reference has been made to the hardness of the muscles of the abdomen, the back and lower limbs. Lately, if he attempts to raise the arms over his head the abdominal muscles stiffen, and taking a deep breath has become difficult because of a tight feeling about the upper chest. Sexual potency has been lessened with the onset of his condition.

Past Medical History.—There was no history of having sustained an injury such as a puncture wound or of having received tetanus antitoxin, nor had he been taking tonic medicine containing strychnine. He has had occasional head colds and fairly frequent sore throat as well as recurring winter coughs with mucopurulent expectoration. He used to have bilious attacks with nauseous headache and occasional vomiting, but they have not recurred in the past few years. He has also been subject to hives especially after eating strawberries, but not for the past five years. He had typhoid fever in 1909, a Neisserian infection in 1908, measles and scarlatina in 1900, and a very extensive carbuncle on the neck in 1925.

Family History.—His mother was asthmatic and died of a stroke at seventy-six years, his father is living and well at eighty-three years. He has three children, one of whom, twelve years old, is diabetic. The patient is an electrical engineer and has lived a moderately active life with no excesses of any kind.

Examination.—The patient is intelligent, mentally alert, well-oriented and co-operative. No impairment in speech is present but as he talks it is noticed that he becomes short of breath and his conversation is interrupted frequently by short coughs and his pulse-rate mounts rapidly; at the same time his gown becomes moist with perspiration and beads of sweat are observed appearing on his face and neck, equally distributed on each side. Occasionally there is a spasm of the neck muscles while he

talks, drawing the head backward. The odor of test substances is recognized normally through each nostril. There is no exophthalmus or enophthalmus, no nystagmus, no von Graefe's sign and the ocular rotations are full; pupils are equal and react well to light and in accommodation. The media are clear, the disks are flat in both eyes with no evidence of choking, neuritis or pallor. The arteries are perhaps somewhat reduced in calibre but no discrete lesions are seen. The visual fields are full to several sizes of test objects and color. Sensation of the face is normal and the corneal reflexes are active. Masticatory power is good on each side and there is no deviation of the jaw on opening the mouth which is done fully. The several facial movements are done normally and equally well on each side, but as he retracts the corners of his mouth a visible contraction of the platysma is observed suggesting some increase of tone in this region. Tests for function of the eighth nerves and the remaining cranial nerves are entirely normal.

The patient is slow in attaining the standing position, but when he does so he stands with head erect, neck slightly stiffened, spine rigid and arms straight against his sides. (The resident physician on the service remarked that he acts like a tin soldier.) As he walks, the right leg is spastic but without limp and without bending of the knee. The arms swing a little stiffly, the right one seems to swing a little more than the left. When asked to pick something from the floor the patient carefully

FIG. 1.—Rigid back.

FIG. 2.—Sandbag-like feel of muscles.

bends his knees and hips, holding the back rigid, and has great difficulty in reaching the floor with the fingers. While doing this he does not look down to see where the object lies. He cannot rise to a sitting position from the supine without the aid of his hands. He has great difficulty in getting up from the floor and several times his arms gave way and he fell back to the floor. It was suggested that he turn over on the abdomen and attempt to get up as a patient with muscular dystrophy, but he was unable to accomplish this because of inability to flex the knees and hips; a chair had to be placed before him so that he could pull himself up. These efforts produced intense perspiration with a pulse-rate of 160 and respirations of 48 per minute with much dyspnœa and a hacking cough, followed by extreme exhaustion. The upper extremities are normally developed, the tone of the muscles being somewhat increased. The finger to nose and past-pointing tests are accurately performed but the movements are slow at the outset and rapid at the completion of the act. There is no loss of power but there is some resistance to passive motion. The dynamometer readings are right 165, left 150 (being right-handed). The biceps, triceps and wrist jerks are normal on each side when there is sufficient relaxation to elicit them. The Troemner reflex is not obtained on either side. The lower extremities are normally developed and the muscle bundles are very prominent in all of the muscle groups because of an increased state

of tone and contraction. The heel to knee test is performed well on each side but with pain in the right hip as the right heel is moved from the patella to the ankle of the left leg. The patellar reflexes are exaggerated on both sides, the achilles reflexes are present but difficult to elicit because of the muscular hypertonus. No pathological toe reflexes are present. There are normal responses to touch, pain, heat and cold, vibration, passive motion and position, graphesthesia and stereognostic perception in all parts of the body.

At no time during the period of observation were the abdominal and lumbar muscles found to be relaxed. His back is constantly in a state of exaggerated lumbar lordosis and markedly rigid while the abdominal muscles are firmly contracted and have a sandbag-like feel. (Figs. 1 and 2.) The muscles of the lower extremities are firmer than normal, limiting active and passive excursions of the various segments of the limbs. During sleep the abdominal and spinal muscles were found to be markedly contracted, but the rigidity was not quite as marked as when awake. Rotation of the head laterally is limited and the contracting sternocleidomastoid muscle stands out in bold relief with great firmness. Movements of the joints of the upper extremities are not limited but, as stated above, there is slowness in their execution. Flexion and extension of the hips, knees and ankles are less than normal on both sides, being more limited in the right hip and both knees. There is a moderate degree of atrophy of the left shoulder-girdle, especially marked in the supra- and infraspinatus areas. No other muscle group shows atrophy. During the height of the sympathetic nervous manifestations, there occurs a marked flushing of the chest and neck as well as a fine tremor of the extended fingers. At no other time has there been observed a tremor of any part of the body. Fibrillary twitchings were not seen in any part of the trunk or limbs. Tests for myotonia were negative. He could alternately open and close the hands rapidly without myotonic disability at the outset of the movement nor was perseveration present. Tapping the tongue, small muscles of the hands, and the individual muscles of the limbs did not cause a myotonic indentation as is seen in cases of myotonia. No myotonic reactions could be demonstrated with the electrical currents, but it was observed that the excitability of the muscles most severely affected was reduced to the faradic and galvanic currents but no qualitative alteration could be detected. The electrical reactions of the left shoulder muscles were not degenerative in character. The skin shows no lesions.

X-ray examination of the skull showed the pituitary fossa to be slightly enlarged, AP 14 millimetres, depth 10 millimetres, the head being otherwise negative. X-ray examination of the spine, shoulders and hips was negative. The only finding in the nose and throat examination was a tonsillar stump on the left side, the sinuses being all clear. "Despite normal auscultatory findings, normal electrocardiogram and orthodiagram, the extreme lability of cardiac rate, especially on exertion, suggests the possibility of some myocardial derangement. On the other hand, the tachycardia may be entirely of nervous origin." (Report of Dr. A. Margolies.) The prostatic examination and smear gave negative results.

Laboratory Examinations.—The blood-count was normal. The blood Wassermann was negative; the spinal fluid was not examined. Blood chemistry: urea nitrogen 19 milligrams, uric acid 3.3 milligrams, creatinine 1.4 milligrams, serum calcium 10.2 milligrams and serum phosphates 3.5 milligrams per 100 cubic centimetres of blood. Sugar tolerance test was normal. Routine urinalyses were negative. Creatininuria was 1.4 milligrams per 100 cubic centimetres. Creatinuria could not be demonstrated after a three days meat-free diet. The basal metabolic rate could not be determined because of the extreme nervousness of the patient at each attempt. The fluid intake and output varied greatly on account of the hyperidrosis.

Comment.—On cursory examination I was impressed by two features, the rigid spine and the myotonic state. The patient emphasized these two

features stating that he was unable to bend his back and had great difficulty in arising from a chair and starting to walk, but after several moments of effort the spasm lessened and he was able to walk with less difficulty. Much of his difficulty was experienced at the outset of a voluntary act involving the trunk and lower limbs, and in the absence of evidence of organic central nervous system disease, a diagnosis of myotonia acquisita was ventured, but reluctantly, realizing that such a diagnosis meant nothing more than a description of the motor dysfunction. Thompson's disease was not seriously considered because there was not the slightest indication of myotonic symptoms existing before the age of forty-one years, and besides there are no indications in the family history of another case of myotonia congenita. It was evident that the myotonic phase of the symptom-complex was of secondary importance, a myotonia symptomatica. The rigidity and hardness of the contracted muscles were certainly paramount to the myotonic manifestations. In spite of the atrophy of the shoulder-girdle of moderate degree one could not entertain the diagnosis of myotonia atrophica because of the recent development of the condition and the absence of facial atrophy and atrophy of the lower limbs as well as the inability to demonstrate the typical myotonic reactions both to mechanical and electrical stimuli. At no time was I impressed with the slightest similarity between the clinical picture presented by this man and any form of progressive muscular dystrophy for evident reasons. Because of the rigid spine and limitation of motion of the proximal joints, spondylose rhizomelique had to be considered but soon discarded in the absence of spondylitis and negative X-ray findings in the hip and shoulder joints. The diagnosis of hysteria would not have been difficult to accept on account of the very marked emotional coloring given to a number of the symptoms as well as the intense vegetative hyperactivity. For instance, who has not seen ribbon-shaped stools, drenching sweats, tachycardia and rapid respirations under conditions of intense emotional excitement? Were it not for the firmly contracted and sandbag-like musculature of the back and abdomen, one might consider the spasmodic attacks hysterical. It was necessary, therefore, to investigate the condition of the muscles by biopsy to prove or disprove the existence of a generalized muscular affection.

Biopsy.—The rectus abdominis muscle was selected; the tissue was fixed in the routine way and sectioned in the routine fashion. It was found that the details of the muscle structure were not sufficiently preserved by that method. The biopsy was later repeated on the left spinæ erector muscle. At the first biopsy the muscle seemed paler in color than normal and the cut ends of the muscle retracted more sharply than usual. The spinæ erector muscle at the second biopsy appeared normal in color but the subcutaneous tissue was exceedingly thick and the surgeon, Dr. I. S. Ravdin, expressed surprise at this observation. Small freshly excised pieces of muscle and subcutaneous tissue were fixed in Zenker's solution and Susa fixative. They were imbedded in celloidin and paraffin and then doubly imbedded by the celloidin and paraffin method; in that way all shrinkage was avoided. Microscopical examination by Dr. Baldwin Lucke: The subcutaneous tissue showed a very decided increase of supportive stroma in the form of many coarse bands of dense fibrous tissue separating the fat globules of the areolar tissue. This condition seems to have existed a long while

since no cellular reaction accompanies it. In various sections of the muscle tissue there was not to be seen any local or general increase of connective tissue. There were present, however, evidences of some severe degenerative change affecting muscle cells in a scattered, irregular, patchy fashion. While the vast majority of the muscle cells showed beautifully preserved striations, both transverse and longitudinal, there were isolated muscle cells which were swollen and had almost an homogeneous appearance, being diffusely involved, while in other cells these degenerative changes were confined to a portion of the cell-body. In other cells it was found that the mid-portion of the cell-body had lost the striations and that in this region was present a mass of twisted, seemingly broken fibrils forming an irregular network and having a peculiar motheaten appearance. The nature and origin of these fibrils is as yet uncertain. In some other fibres there was evidence of distinct atrophy and in these there was usually seen an overgrowth of the sarcolemma nuclei. A moderate number of swollen fibrils practically devoid of striations appeared sometimes to be vacuolated and presenting the general picture of Zenker's hyaline degeneration. The most conspicuous lesions are, therefore, the occasional swollen and vacuolated fibres with loss of striations; the rather curious degenerative changes in the centre of some cells; and the very marked fibrosis in the subcutaneous tissue. It is to be emphasized that while these changes are very distinct and widely distributed, they are not obvious without a careful search. Although the nature of these changes at present is unknown, it seems proper to use the categorical diagnosis of chronic fibromyositis.

For the purpose of orientation Batten's[1] classification of the inflammatory diseases of muscles was utilized: (*A*) Primary infections—(1) polymyositis including acute polymyositis, dermatomyositis, hæmorrhagic myositis, polymyositis with erythema multiforme and urticaria, and pseudotrichinosis; (2) neuromyositis; (3) tuberculous myositis; (4) syphilitic myositis; (5) myositis due to trichinella spiralis. (*B*) Secondary infection in the course of acute or chronic disease—(1) myositis in the course of specific fevers as typhoid, typhus, smallpox; (2) infective myositis occurring in pyæmia, infective endocarditis, glanders, gonorrhœa, puerperal infection and infected wounds, actinomycosis, erysipelas, etc. (*C*) Myositis with special terminal lesions—(1) myositis ossificans progressiva; (2) myositis fibrosa, general or local.

Assuming our case to be one of a primary muscle disease it would have to be considered a form of chronic generalized myositis. The absence of skin lesions differentiates it from dermatomyositis, and the absence of bone formation in the muscles excludes the diagnosis of myositis ossificans progressiva. Myositis fibrosa remains to be considered. Steiner[2] defines myositis fibrosa as "A single or multiple inflammation of muscles, mostly subacute or chronic, which generally begins in the lower extremities and presents but slight constitutional symptoms. Eventually the muscle tissue is largely or wholly replaced by connective tissue and quite pronounced muscle atrophy may then be observed." Age and sex play no part in the incidence of the disease, the youngest patient reported was nine months old and the oldest forty-eight years old. The onset is insidious, progress is fairly rapid taking but a few months to definite impairment of muscle function. The presenting symptom is usually stiffness of the extremities particularly the lower, with gradual spread to every muscle of the body except the face and lips. Pain

is usually absent, and if present, occurs early and is of short duration. Weakness and progressive loss of weight are outstanding constitutional symptoms but fever has not been reported. Schwab *et al.*,[3] describe what they call an outstanding diagnostic point in the characteristic feel of the muscles on palpation. They state that the muscles feel harder than normal and are of increased consistency. They seem œdematous to the hand without the sensation of subcutaneous œdema and the muscles feel doughy and boggy. Batten refers to the wood-like or sandbag feel as being characteristic and simulated only by the palpatory characteristics of dermatomyositis differentiated, of course, by the involvement of the skin. It is stated by Schwab that in the early stages the muscle volume is preserved but later the muscles decrease in size with shortening and limitation of motion, finally resulting in complete helplessness of the patient. Gies[4] refers to the board-hard feel of the muscles with sensitiveness to pressure and the unyielding thickness of the overlying skin.

Attention is directed at this point to the striking similarity between the syndrome of our case and that of other reported cases. The most recent case report is by Schwab[3] *et al.*, in September, 1932. Their patient began to show symptoms at the age of twelve years, and by the end of seven months he could not bend. There was very little chest movement in breathing which was entirely abdominal. Practically all the muscles of the body were indurated, firmer and stiffer than normal and not unlike a sandbag. The muscle volume was fairly well preserved except the deltoids and pectorals which showed considerable atrophy. The face and lips were uninvolved while the masseters were somewhat contracted and the sternomastoid muscles slightly involved. The trunk and lower limbs were uniformly affected and there was greatly impaired motor power throughout. The gait was somewhat spastic, all the tendon reflexes and sensation were normal. He had constant tachycardia, weakness, progressive loss of weight and attacks of dyspnœa evoked on the slightest exertion. He died three months after admission from pulmonary tuberculosis.

Burton, Cowan and Miller,[5] in 1923, were able to collect five cases in the literature and report the case of a woman, twenty-five years of age, who complained of muscle stiffness with loss of flesh and a stiff, straight, immobile back, since the onset of her disease. All of her muscles were definitely atrophied and they felt firmer and stiffer than normal with a sensation like a sandbag or a piece of wood. Electrical reactions were normal but with diminished excitability. Her skin was always moist. Their patient improved steadily and in 1930, they report that the patient had conquered her previous disabilities and performed many of her duties. She still had considerable disability in the hands but the movements of the lumbar spine were then normal but flexion of the cervical spine was limited. Arising from the prone position, she still "climbed up her legs" as does a case of pseudohypertrophic muscular dystrophy.

Batten's patient was a boy, healthy until nine months old, when his back

became curved and legs drawn up. There was steady progression until at six years he was rigidly fixed in a flexed position and the right sternocleidomastoid muscle was greatly contractured. There was no evidence of disease of the central nervous system. The child died at six years of age. Batten states that the gradual onset, the slow progress of the disease, the fixed position which the trunk and limbs gradually assumed, form a clinical picture which bears striking resemblance to myositis ossificans, but the complete absence of any bone formation in the muscles removes the doubt.

In Schwab's case, on microscopical examination, degenerative, inflammatory and fibrous tissue changes were found in varying degree. There was great variation in the size of the muscle fibres, some larger than normal, others one-fifth the normal size. In many, all the striations were gone; in some, one or the other were gone. Hyaline degeneration and hydropic infiltration were common. Inflammatory cells were scattered about in varying numbers and occasionally in definite collections with more or less complete muscle degeneration; a larger number of these cells were of the lymphocytic group; a small number of plasma cells with large endothelial cells and fibroblasts were present. There were variable amounts of new fibrous tissue and it constituted approximately ten per cent. of the muscle volume. None of the fibrous tissue had reached the adult stage. Microscopical examination of the peripheral nerves was negative. The diaphragm and the myocardium also showed pathological changes. The biopsy in the case of Burton[5] *et al.*, showed general increase of connective tissue with several areas of active inflammatory reaction, marked degenerated muscle elements were observed and many bundles had disappeared while others were atrophic. A few showed hyaline vacuolar degeneration. They found chronic arteritis with limited small cell infiltrations around them. A large number of muscle fibres had lost their transverse striations. Janicke[6] describes the biopsy findings in his case as showing swelling of the mucle fibres with atrophy and granular degeneration of others and loss of the transverse striations with accentuation of the longitudinal striations. The muscle bundles were separated from one another by broad bands of solid connective tissue resembling a hard nucleated fibroma, but a true cell infiltration could not be seen. The muscles in Batten's case when cut seemed to grate and presented a white hard surface on section. Microscopically, there was increased interstitial tissue between the muscle fibres. The fibres had in part undergone granular degeneration, in part simple atrophy with a loss of the striations of the muscle fibres.

As to the etiology of myositis fibrosa, to which I believe this case is allied, little is known. Pemberton[7] states that under the term "myositidies" most authors include fibrositis, myalgia or even myositis. He is of the opinion that the pathological process implied is really part of and belongs to the rheumatoid or arthritic syndrome and that there is every reason to believe that it springs for the most part from the factors causative also of arthritis and should be regarded as an expression in the muscular tissues of the same underlying process. Batten suggested the relationship of myositis fibrosa to

myositis ossificans because ossification in muscle tissue in nearly all cases is preceded by a myositis.

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THE RÖNTGEN DIAGNOSTIC SIGNIFICANCE OF EROSION OF THE OPTIC CANALS IN THE STUDY OF INTRACRANIAL TUMORS

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The true value of Röntgen evidence in the diagnosis and the localization of intracranial neoplasms had its inception in the realization that some brain tumors could produce certain changes in the bones of the skull that were detectable in the röntgenograms. The first to recognize such changes during life was Oppenheim,[1] in 1899. He diagnosed a case of hypophyseal tumor in an acromegalic when he found the sella deepened and widened as though its bony outline had been expanded by a growth. Similar findings were reported by Fuchs,[2] who, with Holzknecht, and without any knowledge of Oppenheim's case, reported a pituitary tumor with the dorsum sellæ absent in 1902. From then on there has been a most rapid advance in the detection and interpretation of bone changes in the skull incident to intracranial tumors. Schüller[3] gives Erdheim the credit for teaching the differentiation between sellar deformation due to hypophyseal tumors and those arising elsewhere.

With very few exceptions we do not find in other parts of the body the wide variety of bone changes due to the close proximity of tumors to bone that occur in the cranium as a result of intracranial neoplasms. The explanation is to be found in theory rather than in fact. Tumors in other regions except the exceedingly hard ones like osteoma and enchondroma do not affect the neighboring bones except by infiltration. Intracranial tumors (aside from those which do infiltrate, as meningiomas, carcinoma or sarcoma, and those which are present in both brain and osseous tissues, as angiomata) seem to affect the bony envelope either by direct pressure or in a manner akin to aneurismal contact elsewhere. Brain tumors or the displaced third ventricle do not differ very materially in density from the normal brain structure, but when they pulsate continuously against the cranial bones marked changes may be produced. The pulsation of an aneurism pressing on a bone will produce an erosion even though the pulsating force is in one direction only, as in the case of the spine, sternum or ribs in aortic aneurism, or the ribs from enlarged intercostal arteries in the collateral circulation arising from coarctation of the aorta. It is probable that the bones of the skull are intended to withstand a certain amount of equalized pressure, and that because of the rich arterial supply of the brain and the resulting pulsation within a rigid bony envelope like the cranium, the trivial but long-continued pressure of the slightly altered density of the tumor or a displaced

ventricle may be the cause of bone erosion in many instances in which it occurs. At times new bone formation occurs synchronously with the eroding process, as in the slowly progressing cases of acromegaly in which the pituitary fossa may become considerably enlarged in depth and in sagittal dimension, without losing much if any thickness of its walls. Any one who is familiar with the changes in the sella as a result of chromophobe adenomata has observed the characteristic deformities caused by the partial enclosure of the tumor in the bony envelope. This occurs almost always after the tumor has grown sufficiently large to affect the optic chiasm, or in exceptional instances, the tracts or nerves.

The pulsation theory seems to explain the erosion in a fairly satisfactory manner. The erosion of the posterior clinoid processes and dorsum sellæ, and later, the general enlargement of the fossa, which may occur with tumors in the posterior fossa or pineal region, can be attributed to the downward enlargement and persistent pulsation of a dilated third ventricle. Certainly this is an unnatural pressure which this part of the bony envelope was not intended to withstand. The slight deformations of the pituitary fossa caused by parasellar tumors, which occur usually in the temporal lobe, in the base of the frontal lobe or even more remotely, usually without direct tumor contact, are more difficult to explain, although the same theory may apply.[4] As a result of these very frequent changes in the sella, the pituitary fossa has assumed great prominence as a locality to be observed and studied for the detection of evidences of brain tumor and even in their localization. Aside from noting calcification or other glaring and self-evident appearances, one acquires the habit of always studying the pituitary fossa first in examining radiographs of tumor suspects.

Thanks to the pioneer work of Towne[5] and others, the enlargement of the porus acusticus by erosion has become a characteristic sign of the presence of the slow-growing acoustic neuroma. In 1934, Ebenius[6] reported thirty-four tumors of acoustic origin, and 80 per cent. showed expansile deformity in the region of the internal auditory meatus, while 15 per cent. more showed erosion in the other neighboring skeletal parts. Some other tumors in this region occasionally deform the petrous ridge by erosion. Tumors of the meningioma group sometimes erode the sphenoid ridges or other portions of the base or even some portions of the vault of the skull, whereas these same tumors elsewhere may cause hyperostosis of the bone overlying or underlying the growth.

A tumor may occasionally cause bulging of some portion of the cranial vault. Whether a combination of bone atrophy on the inside and of reconstruction on the outside are the factors in such an effect is uncertain. These are only some of the many examples of bony defects that might be mentioned.

In this presentation we are particularly interested in erosion of the walls or enlargement of the optic canals as an evidence of intracranial neoplasm. Any case of intracranial pathology deserves the most painstaking study, and

this includes a thorough röntgenological examination. There are sufficient data accumulated to warrant an accurate study of the optic canals in every case in which it may seem to be especially indicated. There are many instances in which it is not, and as the difficult case has to have a maximum amount of exposure on the head, we may restrict the optic canal examinations to those in which it seems to be particularly needed.

In the examination of the optic canals a knowledge of their exact direction is most essential in any technic which may be employed, and the central ray must be directed accordingly. Both canals must be radiographed for purposes of comparison. In a search through the literature on the subject, nearly forty references have been found describing methods and findings. A few of these require mention in order to stress particular points. In 1923, Martin and Cushing[7] reported seven cases of glioma of the optic chiasm or adjacent optic nerves, and in several of these a supposedly characteristic atrophic appearance of the bone was noted in connection with this particular lesion. We have never been able to confirm the appearance described by them. Soon afterwards, Van Der Hoeve[8] reported positive findings in a case of diffuse neurofibromatosis. Goalwin[9, 10, 11] devised a method and studied the canals at all ages and under all possible conditions. In 1927,[11] he reported the findings in 403 living subjects and ninety-seven dry skulls. Among the living, the examination was definitely indicated in 253 cases, and showed twenty-three different pathological conditions in eighty-nine individuals in which they were suspected, of which the following are the most important: fractures of the canal or orbit, hyperostosis, exostosis or osteoma, enlargement by optic nerve tumors, intracranial extension from tumors of the eye, enlargement by destruction of the walls, foreign bodies, deformities due to deformed skulls, arterial calcifications of the internal carotid or ophthalmic arteries and other calcifications in the lumen. He called attention to the fact that the canals varied in direction with age, and may vary also in size and shape to a certain extent. The canal is usually shaped somewhat like the quadrant of a circle. Fortunately, there was absolute symmetry on the two sides in about 45 per cent., differences of 10 per cent. or less in 40 per cent. and differences between 10 to 20 per cent. in only about 14 per cent. His technic was too complicated for general use. White[12, 13] gave an analysis of 164 skulls, demonstrating the relationship between the optic canals and the adjacent sinuses. Camp and Gianturco[14] described a device for use in connection with their technic which was much simpler than that of Goalwin, and which was employed by us for some time. We have more recently employed the device and technic described by Pfeiffer[15] and have found them accurate and easy to follow.

We have employed the examination of the optic canals advantageously in many of the conditions in which it has been advised. In this presentation we are particularly interested in the effects of adjacent intracranial tumors in their eroding influence upon the canals as a means of diagnosis and of localization. The following cases are illustrative:

CASE I.—M. F., female, aged forty-six years, referred from the neurosurgical service of Dr. C. H. Frazier, Hospital of the University of Pennsylvania. The essential points in the history were as follows: Signs of increased pressure evidenced by headaches and vomiting had been noted for a period of two years. There was anosmia. Visual disturbances started three or four months ago. At the time of the examination she was totally blind in the left eye and only sufficient vision remained in the right eye to permit her to read newspaper headlines.

Radiographical Examination.—Our radiographical examination made October 7, 1932, showed a large and irregularly calcified tumor in the frontal region in and to the left of the mid-line. It extended to the base and was apparently connected with the bone. The calcified portion of the tumor measured approximately five centimetres in diameter. The pituitary fossa was unaltered and measured ten centimetres in sagittal direction and ten centimetres in depth by teleröntgenogram. The impressions were that the lesion was a basal meningioma growing from the left side with hyperostosis below, and not springing primarily from the olfactory groove, although the latter had been involved. The tumor extended back to at least as far as the optic nerve. Another

FIG. 1.—(Case I.) Normal right optic canal indicated by the arrow. The canal appears as a bony ring within the orbit and free of the ethmoid cells. Usually the ipsolateral anterior clinoid process can be made out in the film just above and to the outer side of the canal.

FIG. 2.—(Case I.) Eroded left optic canal indicated by the arrow. There is marked thinning of the roof of the canal. The actual destruction involved only the posterior ¼ inch.

examination was made to determine the contour of the optic canals October 12, 1932. The röntgenograms showed that the canal on the left side had thin bony walls, the roof especially having been eroded. (Figs. 1 and 2.)

Operation.—The patient was operated upon by Dr. F. C. Grant and the presence of the tumor was confirmed. She afterwards died.

Pathology.—The autopsy findings were somewhat more exact. The tumor originated from the falx high up on the left side, and extended downward to the base of the left frontal lobe, and then backward over the left orbital plate. The growth was a meningioma and the calcification was found to be entirely within it. There was no *true* hyperostosis such as is often found in connection with meningiomas in this region and in the vault. The orbital plate was not eroded but was slightly thickened. The left cribriform plate was about twice as thick as it usually is. The left olfactory nerve was compressed directly by the tumor but the right was simply compressed by the general pressure in the neighborhood. The left optic canal was considerably involved. The roof of the posterior one-quarter inch was completely destroyed and the left optic nerve was exposed here to direct tumor pressure. Our examination did not show this exactly although it did show marked thinning as compared to the right side. The

blindness in the left eye was due to direct nerve pressure at the entrance to the canal. The pituitary fossa was not affected.

Comment.—In this case a meningioma, a moderately slow-growing tumor, had definitely eroded the roof of the optic canal on one side so that this sign could be used in localization. As a result the optic nerve was exposed to direct tumor pressure. Of course the calcification was an even better evidence for localization. Most if not all of the calcification seen in the lower part of the growth was really of the nature of hyperostosis of the skull. The entire periphery of the tumor was calcified.

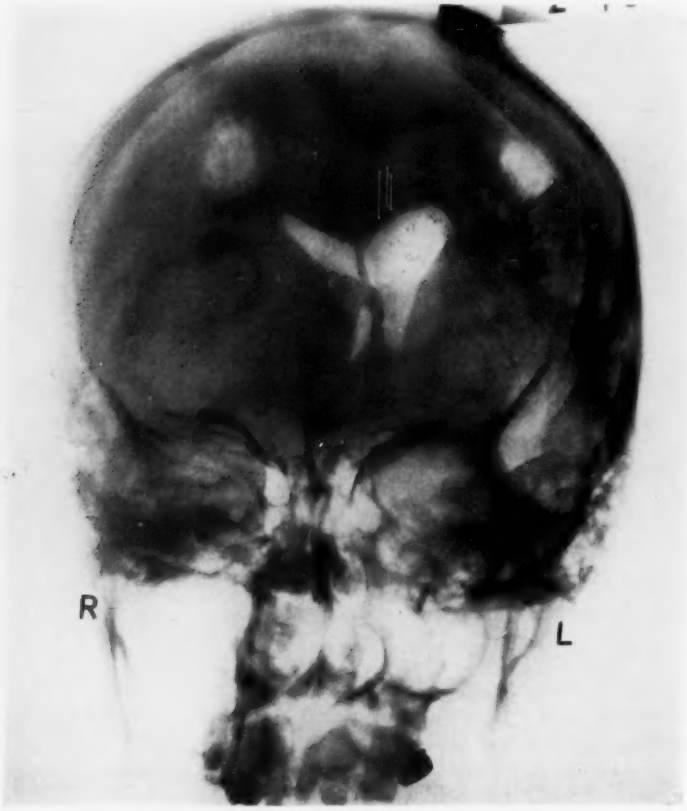

FIG. 3.—(Case II.) Postero-anterior ventriculogram, showing displacement of both of the lateral and the third ventricles to the left side by a right-sided tumor.

CASE II.—E. G., female, aged forty years, referred from the neurosurgical service of the Hospital of the University of Pennsylvania by Dr. F. C. Grant. This case has been previously reported as Case VII by Doctors Alpers and Groff.[16] The essential points in the history were as follows: in November, 1932, she began to have attacks of diplopia. The first attack was followed by blurring of vision. There were no symptoms of a localizing nature, nor of increased intracranial pressure. She was admitted because of the visual disturbances.

Neurological Examination.—Choking was present in the *left* eye of six dioptres and less in the right. Vision in the left eye was 6/9 and 6/12 in the right. There was a

slight degree of *right* facial weakness and a questionable weakness of the right hand. The tongue deviated slightly to the *right*. There was no loss of smell on either side. The few neurological signs were suggestive of a *left*-sided lesion. The cerebrospinal fluid pressure was 350 millimetres of water.

Radiographical Examination.—Our first examination, made February 8, 1933, showed a slight deformation of the pituitary fossa such as is seen in nearby parasellar tumors. This deformity consisted of (1) a slight deepening of the floor on one side, although it was impossible to determine which side was involved, and (2) a slight cortical erosion of the anterior face of the dorsum sellæ, especially below. The posterior clinoid processes were intact. The occipital projection of the dorsum into the foramen magnum suggested that the erosion was on the left side. An examination of the optic canals showed an absence of the roof on the *right* side, although the clinical evidence was in favor of a *left*-sided lesion and the right eye was the less affected. Notwithstanding the clinical localization of a left-sided lesion, more importance was attached to the radiographical evidence of

FIG. 4.—(Case III.) Teleröntgenogram of the pituitary fossa, showing its actual size of 12.5 anteroposterior and 11 mm. depth measurements. There is a slight depression of the floor and a slight anterior erosion of the dorsum sellæ, characteristic of parasellar lesions. Note the calcification in the tumor seen above and in front of the sella.

destruction of the right optic canal. Finally, a ventriculographical examination was made February 15, 1933, just prior to the operation. The air studies gave positive evidence of a large *right* frontal lobe tumor, with displacement of both lateral and the third ventricles to the left side and a filling defect in the right lateral ventricle. (Fig. 3.)

Operation.—A right transfrontal craniotomy revealed a large hard tumor in the tip of the right frontal lobe alongside of but not attached to the falx. It was situated mainly over the mid-portion of the orbital plate and was attached to the dura overlying this portion of the bone. The tumor lay close to the cortex and was about the size of a hen's egg. The posterior portion evidently lay in the middle fossa behind the sphenoid ridge. It was completely removed.

Pathology.—The tumor proved to be a meningioma. An operative sketch of the base of the skull showing the tumor and its relations to the optic chiasm, right optic nerve and the right optic tract indicated that the roof of the right canal was destroyed. The tumor arose from the dura of the sphenoid ridge on the right side. Such tumors may or may not produce an underlying hyperostosis, and this one did not. The question arose whether any direct erosion of the pituitary fossa from infiltration had occurred.

Apparently this was not the case. The deformation of the sella seemed due entirely to parasellar phenomena.

Comment.—This case was the strongest evidence we could have of both the diagnostic and the localizing values of optic canal erosion. The clinical signs were indefinite, but seemed to indicate that the left side was involved, whereas the optic canal erosion pointed to a right-sided lesion. The pituitary deformation was merely suggestive of the general locality of the tumor and of no value in lateralization.

CASE III.—Mrs. E. L., aged forty-two years, referred by Dr. George Wilson for examination October 31, 1932. The essential points in the history were as follows: There were three attacks of loss of consciousness during the past three and one-half years accompanied by stertorous breathing. The right leg became stiff during the last attack. There was choking of three dioptres in the right eye and one dioptre in the left.

Radiographical Examination.—A calcified mass appeared just to the left of the mid-

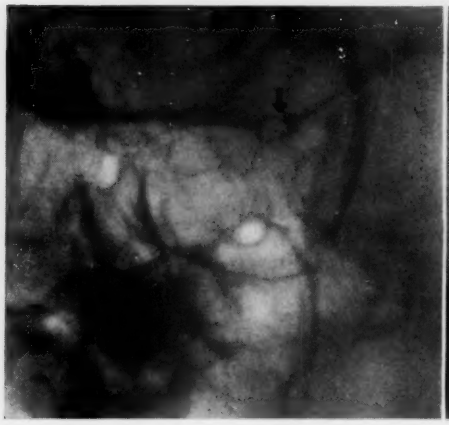

FIG. 5.—(Case III.) Shows the eroded roof of the left optic canal indicated by the arrow.

FIG. 6.—(Case III.) Shows the normal right optic canal indicated by the arrow.

line, partly in the middle fossa and extending over the sphenoid ridge into the floor of the anterior fossa. (Fig. 4.) There was no erosion of the sphenoidal ridge shown at this examination. The sella turcica showed a rather typical appearance produced by a parasellar tumor. There was a slight depression of the floor and a slight anterior erosion of the dorsum sellæ. The teleröntgenogram measurements of the sella were 12.5 millimetres anteroposteriorly and eleven millimetres depth, this being in our experience slightly more than top normal. (Fig. 4.) The radiographs of the optic canals showed a very definite erosion of the roof of the left canal. (Figs. 5 and 6.) There was also some erosion of the left anterior clinoid process indicated in these views but not detected in the lateral röntgenograms. (Fig. 4.) A further examination was made May 12, 1933, over six months later, and a definite change in the appearance of the sella was noted. (Fig. 7.) Considerable erosion in the floor of the fossa and further atrophy of the dorsum had occurred. The measurements were now fourteen millimetres anteroposteriorly and eleven millimetres in depth. Stereoscopically erosion of the left sphenoidal ridge was now visible. Our conclusions were that the patient probably had a meningioma arising from the left sphenoidal ridge near the mid-line and eroding the left optic canal.

Operation.—The patient was operated upon by Doctor Frazier May 16, 1933. On

lifting up the left frontal lobe the tumor was exposed about one inch below the surface. The growth was sufficiently firm to suggest fibroblastoma, but no sharp definition was found. The biopsy showed it to be an astrocytoma of a very fibrillary type. The tumor extended backward behind the chiasm and slightly to the right of the mid-line and was flanked at the mid-line for a considerable distance by the falx.

Comment.—This firm and rather rapidly growing tumor was not a meningioma, yet it eroded the optic canal. This erosion was in this particular instance only of confirmatory value since the calcification in the tumor mass clearly localized it.

The sign of optic canal erosion may be an evidence of tumor, but it cannot always be depended upon for localization purposes, as is illustrated in the following case:

FIG. 7.—(Case III.) Further examination of the pituitary fossa made over six months later and showing further changes in the floor and dorsum sellæ and the increase in measurements to 14 mm. anteroposterior and 11 mm. depth.

CASE IV.—C. C., female, aged forty-three years, was referred for examination from the service of Doctor Frazier, Hospital of the University of Pennsylvania. The essential points in her history were as follows: Attacks of "semi-vertigo" had occurred for the past year but without loss of consciousness or falling. The vision had been blurred since September 7, 1932, but there was no diplopia. There were periods of nausea for the past few months but no vomiting. Her mother died of a brain tumor at the age of fifty-five years.

Neurological Examination.—This revealed probable personality changes and poor memory for recent events. There was diminished vision, bilateral choking of three to four dioptres and an atypical left homonymous hemianopsia. She had lower left facial weakness, inconstant spasticity of the left forearm and hand, increased left tendon reflexes, left ankle clonus, *right*-sided anosmia, diminished libido and dysmenorrhœa. Clinically, a right-sided tumor was suspected.

Radiographical Examination.—The partial examination made October 21, 1932, was negative except in showing a pituitary fossa which suggested a parasellar tumor because of the considerable atrophy of the dorsum sellæ without definite enlargement of the fossa. Accurate measurements could not be made. A routine examination of the optic canals was not made at this time.

Operation.—The patient was operated upon by Doctor Grant October 27, 1932, through a right frontotemporal bone flap. A transverse cortical incision was then made parallel to the falx. At a depth of about two centimetres a pinkish mass was found, fading off into brain structure. A large portion of this mass was removed and this led down into what was thought to be a cystic area deep in the temporal lobe, although no fluid was encountered. It was very difficult to find a definite line of cleavage between the tumor and the brain. A mass about three centimetres in diameter was removed. The tumor bed was filled with cotton wrung out in Zenker's fluid. Two-thirds of the bone flap was removed low down over the temporal lobe. The dura was opened widely down to the temporal fossa and drawn back over the motor cortex, and the area anterior to this edge of the dura was covered with cellophane. The cotton was then removed from the bed of the tumor. Before applying the final dressing a frontal trephine was made and through this the left lateral ventricle was tapped and twenty cubic centimetres of fluid withdrawn.

Pathology.—An autopsy revealed a large *right*-sided frontotemporal infiltrating astrocytoma which had displaced the lateral and especially the third ventricles to the *left*. The position of the third ventricle was such that it impinged upon the *left* anterior clinoid process and the roof of the *left* optic canal, causing erosion of both.

Post-mortem Radiography.—A further Röntgen examination was made before autopsy was performed for the purpose of radiographing the optic canals. This showed erosion of the *left* optic canal roof and anterior clinoid process.

Comment.—This case is an exception to the first three for the reason that the displaced third ventricle and not the tumor caused the optic canal erosion on the side opposite to the growth. This localizing sign might have been very misleading had the canals been examined before the operation. The misleading result of the examination for optic canal erosion in this instance emphasizes the advisability of ventriculographical studies in all such cases in which the clinical localization is in doubt, especially as to laterality, provided there are no other Röntgen localizing signs as calcification.

CONCLUSIONS

(1) Three cases are cited in which erosion of the roof of one optic canal was a dependable sign in the localization of a brain tumor.

(2) Calcification was a further localizing sign in two of the cases.

(3) In one of the three cases the erosion was found on the side opposite to that indicated by uncertain clinical signs. A ventriculographical study was necessary for final accurate localization.

(4) In a fourth case the erosion occurred on the side opposite to that indicated by clinical localizing signs, operative findings and autopsy confirmation. Fortunately, this examination was made after death and the erosion was found to be due to the laterally displaced third ventricle.

(5) As all of the optic canal findings were essentially the same in the four cases, those of only two of the cases are reproduced.

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GLOSSOPHARYNGEAL NEURALGIA

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Although the course of the glossopharyngeal was clearly described by Galen and the nerve separated as a distinct entity by Fallopius, the actual functions of the nerve were unknown and its typical neuralgia unrecognized until recent years. Weisenburg,[18] in 1910, first described the symptoms of glossopharyngeal neuralgia. These were due, in his case, to a cerebellopontile angle tumor pressing upon the ninth nerve. The sensory root of the fifth nerve was also involved, producing trigeminal neuralgia. Frazier sectioned this root with complete relief of pain in the fifth nerve distribution, but of course the ninth nerve neuralgia persisted. The case was regarded as an example of failure to relieve trigeminal neuralgia by section of the sensory root until, six years later, autopsy revealed the true cause. The fifth nerve pain had been relieved, but the additional ninth nerve irritation had not been recognized.

True glossopharyngeal neuralgia was first described by Sicard and Robineau,[16] in 1920, but they were not certain of its purely ninth nerve origin. Accordingly, they sectioned not only the glossopharyngeal, but also the cervical sympathetic and the pharyngeal branches of the vagus. A year later Harris[10] reported two cases, the first of which he had injected with alcohol ten years previously under the erroneous diagnosis of trigeminal neuralgia involving the third division. This mistake has been frequently reported by subsequent authors.

Doyle[6] was the first to report cases of glossopharyngeal neuralgia in this country and Adson[1] the first to operate upon them here. He had followed the technic of Sicard and Robineau, but recommended for future operations intracranial section of the ninth nerve to prevent regeneration. This was first performed by Heath as reported by Miller[13] in 1925. Unfortunately, his patient died on the third day, apparently from pulmonary œdema. Fay,[7] in 1926, reported intracranial division of the nerve for carcinoma of tongue and pharynx. In February, 1927, Davenport, as reported by Bailey,[3] also sectioned the nerve intracranially for glossopharyngeal pain which was later found due to an epithelioma of the larynx infiltrating the pharyngeal wall. Apparently the first extracranial division of the glossopharyngeal nerve was performed by the writer in 1919 for excruciating pain due to a carcinoma of the base of the tongue. Complete relief was obtained.

The first successful intracranial section for true glossopharyngeal neuralgia was performed by Dandy in April, 1927. This was followed shortly by similar successful operations by Adson, Stookey, Grant, and Peet. Since then several other surgeons in this country have reported excellent results, but in

Europe the extracranial approach is still favored. In my opinion the intracranial operation is not only equally safe, but easier, faster, less likely to damage the vagus, and above all, is certain assurance of permanent relief.

While glossopharyngeal neuralgia is rare compared to trigeminal neuralgia, it undoubtedly occurs much more frequently than the reported cases indicate. When Dandy[5] reported his first two cases in 1927, he collected eighteen cases from the literature. Keith,[12] in 1932, collected seventeen additional cases, and others have been reported by Usadel,[17] Jefferson,[11] Reichert,[15] Filatov,[8] Noltenius, Chavany,[4] Ball,[2] and Peet.[14] Fourteen personally observed cases are reported in this paper.

The first accurate knowledge of the function of the glossopharyngeal nerve was obtained by Dandy when he divided the nerve intracranially. All previous observations had been made on relatively gross injuries, either from tumors or trauma. In all of these some fibres of the vagus had been injured as well as the glossopharyngeal nerve and functions had erroneously been accredited to the latter which in reality belonged to the former.

Dandy showed that there was no demonstrable motor function in the ninth nerve, the pharyngeal muscles being normal after its intracranial section. Anatomists state that the stylopharyngeus muscle is supplied by the ninth nerve, but paralysis of this muscle cannot be demonstrated. Taste was shown to be lost in the posterior third of the tongue on the operative side, and in one case apparently slightly diminished even on the anterior two-thirds. This has no clinical significance as only through very careful testing is the patient aware of any change. No disturbance of salivary secretion was detected.

The sensory distribution of the glossopharyngeal nerve was shown to be the posterior third of the tongue, the anterior, lateral, and posterior walls of the pharynx from the lower nasopharynx to the epiglottis, including its posterior aspect the tonsil, pillars, Eustachian orifice, and a narrow rim along the front of the soft palate including the uvula.

Examination of our patients after intracranial section of the ninth nerve has given essentially the same sensory distribution, but in some cases the line of demarcation between the areas supplied by the fifth and ninth nerves was not sharp. In these there was evidently considerable overlapping by the fifth nerve onto the ninth nerve distribution. This made a border of diminished sensation about the anæsthetic areas at base of tongue, tonsillar fossa, and anterior part of soft palate. In a few instances there was no area of complete anæsthesia, although the gag reflex was lost and sensation in the lateral and posterior pharyngeal walls was markedly reduced. As a rule the sensory change occurred in the mid-line, but in some cases the anæsthesia extended slightly across the middle or, conversely, did not quite reach the mid-line. In no instance was the patient aware of any sensory loss except when carefully tested.

The symptomatology of glossopharyngeal neuralgia is remarkably uniform. The onset is without prodromal symptoms or other warning. Suddenly while talking or swallowing, a sharp, knife-like pain shoots downward

from the ear, the base of the tongue, or the posterior pharynx. It is gone as quickly as it appeared. The initial attack has frequently occurred while drinking cold water. As a rule, even the first paroxysms are described as excruciating, but in exceptional cases the patients state the initial attack was mild though the pain was sharp in character. A few have felt only slight twinges before the onset of major attacks. In these rare cases the insidious onset is usually of short duration, agonizing pain generally appearing within a day or two.

In some cases the pain is initiated by touching the pinna of the ear, and the pain may be confined to the deeper parts of the ear for long periods. Geoffrey Jefferson described a case of thirty-six years' duration in which the pain was confined to the ear for thirty years. One of my patients could induce an attack by moving the auricle forward and backward. Those having pain deep in the ear often thrust the finger into the external canal with a sort of frenzied screwing motion during a paroxysm, as though this gave some relief. Some could initiate an attack by rubbing the ear, the posterior auricular region, the upper neck, or the angle of the jaw. While most of those having pain deep in the ear described the pain as shooting downward, some have stated that the pain darted upward from the throat to the ear.

Talking, laughing, coughing, yawning, or sneezing may be the exciting factor, but swallowing is the most common, especially either hot or cold liquids, particularly the latter. Even the unconscious swallowing of saliva initiates many attacks in some individuals. This may become so distressing that the patient keeps the head tilted forward to allow the saliva to drain from the mouth rather than risk a single swallowing motion. Some patients have pain at every attempt to swallow food, others suffer excruciatingly when the first bolus reaches the pharynx, but can then swallow several times more, if in quick succession, without inducing further pain.

Usually each paroxysm consists of many flashes or streaks of pain, each only a fraction of a second long, but the entire attack may persist for one or two minutes. More often, the longer attacks sometimes described are due to a series of paroxysms, one following the other in such quick succession as to appear continuous for several minutes. During a single paroxysm the patient often grabs the angle of the jaw or presses firmly on the ear or throat. As the pain leaves there is a moment of relaxation, then another grab or tightening of the muscles as quickly recurring pain strikes again.

The paroxysms occur most frequently during the day, some patients being entirely free while asleep. However, when pain is felt at frequent intervals during the day it may awaken the patient at night.

The attacks of pain are subject to intermissions and remissions. The intermissions vary from a few minutes to hours or even a day or two. They are exceedingly irregular, even in an individual case, some days the pain appearing at every attempt to swallow, or spontaneously at frequent intervals. Perhaps the next day the attacks are relatively infrequent or occur only when eating. But the following day they may recur with startling rapidity.

Remissions of several weeks are common and not infrequently the periods of complete freedom extend for months. A few cases are reported with remissions of one to three years and Keith reports one of eight years. During these periods none of the usual exciting factors such as talking, swallowing, or even direct stimulation of former trigger spots will induce an attack.

There is apparently no sex predilection; in a series of fifty-nine cases thirty-three were males and twenty-six females. The youngest was twenty-one, the oldest seventy-five. The majority of cases occur in middle life.

The similarity of glossopharyngeal to trigeminal neuralgia is striking. Both appear with startling abruptness. In each the pain occurs in paroxysms and is variously described as sharp, shooting, lancinating, knife-like, jabbing, flashing, a ball of fire—all descriptive terms indicating a sudden, electric-like pain of agonizing intensity. In both the pain appears spontaneously and on direct irritation of certain regions, called trigger zones, and by talking, laughing, or eating. Both are characterized by intermissions and remissions. In each the pain may be confined for long periods to a single division of the involved nerve. Physical examinations in both are negative with reference to the painful areas. The diagnosis is made entirely on the history and the induction of pain by touching trigger zones. No etiology or pathology is known. The term tic douloureux should be limited to trigeminal neuralgia.

Glossopharyngeal neuralgia differs from trigeminal neuralgia in only one important point, the distribution of the pain. In the former it occurs in the pharynx, tonsillar fossa, base of the tongue, or deep within the ear, *i.e.*, in the areas supplied by the ninth nerve. Trigeminal neuralgia is confined to one or more divisions of the fifth nerve, most frequently the second and third. True, some patients appear to have pains radiating beyond the known anatomical distribution of the fifth or ninth, but the point of greatest intensity is always in an area supplied by the affected nerve.

Additional differential points are the location of the trigger zones when present, and the more common exciting movements. The trigger zone in trigeminal neuralgia is most frequently in the upper lip near the alæ of the nose, but may be anywhere in the fifth nerve distribution. In fact, it is not necessarily located in the branch subject to paroxysms. The trigger zone in glossopharyngeal neuralgia is usually in the posterior pharynx or tonsillar fossa, but may be in any area supplied by the ninth nerve. In a few cases the trigger zone has been in the pinna, a phenomenon not adequately explained by the known distribution of ninth nerve fibres in the ear. Thanks to these trigger zones a safe differential diagnosis is easily made if pain can be induced by touching such an area. For example, pains shooting along the lower jaw induced by touching either lip indicates trigeminal neuralgia. A paroxysm in the throat, tonsillar region, or base of tongue following stimulation of any of these regions signifies glossopharyngeal neuralgia. Cocainization of a ninth nerve trigger zone will temporarily stop the pain.

In fifth nerve neuralgia the pain is most frequently induced by washing or otherwise touching the face, talking, or eating. In ninth nerve neuralgia the

pain most often follows swallowing. While talking may induce pain in both diseases, it is much more frequently the principal factor in trigeminal neuralgia. The movements of eating may likewise bring on an attack in either neuralgia, but in trigeminal it is the chewing movements or contact of the food with cheek or anterior part of tongue which causes pain, while in glossopharyngeal neuralgia it is the act of swallowing which causes trouble. Many patients with trigeminal pain state they are all right if they can get the food to the back of the throat. The reverse is stated by the sufferer from ninth nerve neuralgia.

With one exception all cases of glossopharyngeal neuralgia have been unilateral. In this, Case IX, the pains appeared first on the left side in the posterior pharynx and tonsillar region. Later similar attacks occurred in the posterior part of the tongue and tonsillar fossa on the right. The right and left sides were never afflicted simultaneously. This patient also had typical left trigeminal neuralgia and had been operated upon for this condition a few weeks previous to the onset of the left glossopharyngeal neuralgia.

Combined glossopharyngeal and trigeminal neuralgia is apparently rare. There are five cases in my series of fourteen ninth nerve neuralgias, but no others are reported in the literature. It might be assumed that these were cases of mistaken diagnosis as has frequently been reported, or that they were due to a cerebellopontile angle tumor as in Weisenburg's case. Four were operated upon with intracranial section of the ninth nerve, so the possibility of a tumor can be definitely ruled out. We also feel positive about the correctness of the diagnosis. In each case typical trigeminal pains were felt in the distribution of one or more branches of the fifth nerve. These attacks could be precipitated by stimulation of trigger zones in the area supplied by this nerve. The independent attacks of glossopharyngeal neuralgia were equally typical, always felt in the distribution of this nerve, and were induced by touching the posterior pharynx or tonsillar fossa. In three the paroxysms started in the fifth nerve distribution; in the other two the ninth nerve was first affected.

In one, Case VII, trigeminal neuralgia involving the first and second divisions had been present for twenty-five years, while the glossopharyngeal neuralgia was of only ten or fifteen years' duration. She was certain of two distinct neuralgias, although the pain was of the same character. She stated that the pain in the forehead, eye, cheek, and upper lip was usually brought on by talking, although a cold breeze striking the face would also induce an attack. Touching the margin of the right nostril was almost certain to bring on a severe paroxysm. On the other hand, the pain which radiated from the throat to the ear was started only by swallowing. The pains never appeared in both locations simultaneously. Complete relief was afforded by section of the sensory root of the fifth and the ninth nerves. In this case a mistake in diagnosis could scarcely be made even if the history of each neuralgia had not been so typical, since the trigeminal pain never involved the third division, the only one which might be confused with glossopharyngeal neuralgia.

Case VIII is very similar, the trigeminal neuralgia involving only the first and second branches, the third, where confusion might occur, being at all times free of pain.

Conclusive proof of the presence of both glossopharyngeal and trigeminal neuralgia is furnished by Case IX. In this patient typical trigeminal neuralgia was first noted in the second and third divisions on the left side. Accordingly, a partial section of the sensory root of the fifth nerve was made, the fibres going to the ophthalmic portion being preserved. All pain was abolished and complete anæsthesia was present in the distribution of the second and third divisions. A few weeks later typical glossopharyngeal neuralgia developed on the same side and later the trigeminal neuralgia appeared in the first division which had been preserved at the previous operation. In this case no confusion could exist as the glossopharyngeal neuralgia developed after the second and third divisions of the trigeminal were anæsthetic. Final proof was the return of trigeminal pain in the uncut first division. Both nerves were sectioned intracranially, ruling out the possibility of a tumor. Finally, the patient developed glossopharyngeal neuralgia on the opposite side.

The following fourteen patients with glossopharyngeal neuralgia have been observed at the University Hospital. Twelve were operated upon.

Case I.—Right glossopharyngeal neuralgia. F. D., 213154, male, aged fifty-five. Admitted to the neurosurgical service March 24, 1929, complaining of pain in the base of the tongue and right side of the throat. In August, 1927, he was suddenly seized with a severe pain at the base of the tongue and right side of the throat while swallowing. He had from fifteen to seventy attacks a day, practically every time he swallowed, for a period of one month. He was then free of pain until April, 1928, when he had two attacks in one day. He was again free of pain until February 25, 1929, since which time pain had been suffered daily. Immediately after a paroxysm he would be able to swallow six or seven times before the pain again appeared. Pain was described as sharp, cutting and shooting. It involved the posterior third and base of the tongue, the tonsillar fossa and posterior pharynx on the right side and shot upward to the upper pharynx. The severe paroxysms lasted from five seconds to possibly one-half minute. Except for glossopharyngeal neuralgia his past history, physical and neurological examination were entirely negative.

Course.—March 25, 1929, under local anæsthesia, a small defect in the right occipital bone was made, the cerebellum lifted and the ninth nerve sectioned. Immediately after operation the patient was completely relieved of pain and aside from a slight wound infection his post-operative convalescence was entirely uneventful. He was discharged on his twelfth post-operative day, completely free of pain. Neurological examination showed anæsthesia of the posterior third of the tongue on the right side, the right side of the uvula, and the region of the tonsillar fossa.

Case II.—Right trigeminal and glossopharyngeal neuralgia. E. L., 218284, male, aged sixty-three. June 5, 1929. Six years ago he first noted a shooting pain in the right cheek near the angle of the mouth passing into lower lip. There was a definite trigger zone on the lower lip. There have been frequent periods of complete freedom. Nine months before admission he first noted a stabbing pain beneath the right ear. The pain shoots down beneath the angle of the jaw. He has also had shooting pains in the base of the tongue on the right and reported to his home physician that his pain had also involved the right tonsil, but denied this to us. Chewing brought on stabbing pain. Examination was negative except that touching the lower lip induced pain in the third

division of the fifth nerve and touching the base of the tongue induced pain in that region. A diagnosis of glossopharyngeal and trigeminal neuralgia was made and operation advised. He did not return to the hospital for this treatment.

CASE III.—Right glossopharyngeal neuralgia. F. G., 230788, female, aged twenty-three. Admitted to the neurosurgical clinic November 27, 1929, complaining of pain in the right side of the face, throat and neck. Onset of pain began seven weeks prior to admission. The pain originated just posterior and below the right ear and extended down the right side of the neck and inside the throat. It was described as severe and knife-like, coming on in attacks of sudden onset and lasting for about one minute. One attack followed another, pain seeming to be most severe on the right side of the tongue. The attacks were increasing in frequency and were thought to be initiated by drinking, eating, talking, and exposure to cold.

Past history, physical, and neurological examinations were irrelevant. The patient had three attacks of pain during the examination. During each she clutched the right side of her neck with her hand and remained motionless for about a minute. She would then relax, saying that the pain had disappeared.

Course.—November 29, 1929, under amytal and local anæsthesia, through a unilateral cerebellar approach, intracranial section of the ninth nerve on the right side was done. Her post-operative convalescence was entirely uneventful, she was completely relieved of pain and was discharged on the tenth post-operative day. Post-operative examination showed complete anæsthesia on the right side in the tonsillar fossa, posterior and lateral walls of the pharynx, base of tongue, half of uvula, and in a narrow crescent along border of soft palate.

CASE IV.—Left glossopharyngeal neuralgia. A. V., 234807, male, aged forty-seven. Admitted to the neurosurgical service March 14, 1930, complaining of pain in the left side of the throat. The first attack had appeared seven years prior to admission, subsequent attacks becoming more frequent and more severe. There had been remissions of varying length, some of several months' duration. The pain was described as excruciating and knife-like in character, beginning in the throat on the left side and radiating down the left side of the neck and also upward to the ear. There was no pain in lower jaw or anterior part of the tongue. The attacks were usually initiated by swallowing, talking, or chewing, but also occurred spontaneously. For a month prior to admission the attacks had been of daily occurrence, and for the last two weeks had occurred at five-minute intervals, each with a duration of several seconds. Past history and physical examination were irrelevant. Neurological examination showed a trigger zone to be present in the left anterior tonsillar pillar.

Course.—March 15, 1930, through a unilateral cerebellar approach, intracranial section of the left ninth nerve was done. His post-operative convalescence was entirely uneventful and he was completely relieved of pain. Neurological examination after operation showed anæsthesia in the left posterior pharynx, tonsillar fossa, base of the tongue, and left half of the uvula. Gag reflex was lost on left, normal on right. Pressure sensation was present on left. He was discharged on his eleventh post-operative day, completely free of pain and in good condition.

CASE V.—Right glossopharyngeal neuralgia. C. R., 239869, male, aged forty-six. Ever since the influenza two years ago he has complained of occasional sharp knife-like pain in the right side of the throat which radiated to the right ear. The pain came and went suddenly. It lasted only a minute or two, and was brought on by swallowing. There was no difficulty in swallowing during the frequent periods when he was pain-free, but when the neuralgia was present he had great difficulty swallowing and the throat seemed full. Examination May 7, 1930, was entirely negative except for a definitely diminished gag reflex on the right side. A diagnosis of right glossopharyngeal neuralgia was made and operation advised. The patient failed to return to the hospital for treatment.

CASE VI.—Right glossopharyngeal neuralgia. S. A., 247280, female, aged sixty-seven. She was admitted to the neurosurgical service August 18, 1930, complaining of

pain in the neck and throat. The patient had been having attacks of severe pain in the right side of the neck, throat and mouth for the past five years. Each attack characteristically began with a sudden onset of very severe pain originating in the right side of the neck below the ear, and radiating down on the inside to the base of the tongue, posterior pharynx, and floor of the mouth. The attacks were most frequent in the mornings soon after rising and gradually became less severe as the day went on. Each attack lasted about one minute and they occurred at about fifteen-minute intervals. Past history, physical and neurological examinations were negative except for demonstration of a trigger zone in right posterior pharynx. Several paroxysms of pain occurred spontaneously, or on swallowing during the examination. In each instance she grasped the lower jaw and pressed firmly below the ear and upper neck with her thumb.

Course.—August 19, 1930, through a unilateral cerebellar approach, the right ninth nerve was sectioned intracranially. She was completely relieved of pain and her post-operative convalescence was entirely uneventful. Examination showed markedly diminished sensation, but not complete anæsthesia in tonsillar fossa and base of tongue. The right half of the uvula and a narrow border on the soft palate were anæsthetic, as was the posterior pharynx. Pathological examination of a piece of the ninth nerve removed at operation showed no pathology. She has been free from pain since.

Case VII.—Right trigeminal neuralgia, first and second divisions, and right glossopharyngeal neuralgia. M. A., 251848, female, aged sixty-four. She was admitted to the neurosurgical service October 21, 1930, complaining of excruciating attacks of pain in the right side of the face and right side of throat and neck. The former had been present periodically for twenty-five years. It had gradually grown worse, more severe and more frequent. Sixteen years prior to admission she had had an alcoholic injection with some relief. She now had attacks of pain in two distinct locations. The more recent was brought on by swallowing, and radiated from the side of the throat upward into the ear. The other involved the right side of the face, upper lip, eye, and forehead. This was initiated by a cold breeze striking the face, and by talking. She emphasized that she had two different pains which came on in different locations, and at different times. While the trigeminal pain was of twenty-five years' duration, the glossopharyngeal had been present for only ten or fifteen years. The onset of each was sudden, the pains were similar in character, being sharp and knife-like, and cessation was equally sudden. Morphine had given no relief. There was a trigger zone at the margin of the right nostril which often initiated an attack in the face. She was asymptomatic between attacks. Past history was otherwise negative. Physical examination showed a moderate cardiac enlargement and a hypertension of 172/106. Neurological examination was essentially negative.

Course.—October 22, 1930, under avertin anæsthesia, through a unilateral cerebellar approach, the right ninth nerve was sectioned intracranially. The fifth nerve could not be exposed through the small incision without undue pressure upon the cerebellum. Accordingly, through a temporal approach, the entire sensory root of the right gasserian ganglion was divided. Her post-operative convalescence was entirely uneventful. The patient was completely relieved of pain and was discharged on the seventh post-operative day. There was complete anæsthesia in the distribution of the right fifth and ninth nerves. She has remained free from pain.

Case VIII.—Left glossopharyngeal and left trigeminal neuralgia. E. K., 157977, female, aged fifty-three years. Admitted to the Department of Neurology in the University Hospital November 24, 1926, complaining of a sharp pain which burned and jerked deep in the mouth near the base of the tongue and radiated to the region of the left ear. This had been present for approximately five years. The pain seemed to be deeply situated. It came on in paroxysms, each characterized by its sudden onset, a terrifying pain of almost instantaneous duration shooting into the base of the tongue and upward into the ear. The pains recurred at intervals of a few minutes, sometimes day and night for weeks and months. There had been intervals of two to three months when she was free from pain. Talking, swallowing, especially cold drinks, and clearing the

throat often brought on pain. If saliva collected in the throat it initiated an attack, even though she did not attempt to swallow it. Spitting out the saliva would relieve the attacks for a few minutes. She said she had educated herself to swallow smaller amounts of food than normal and to swallow them "suddenly." She felt that pressure applied back of the angle of the jaw allowed her to swallow more readily. Touching or washing the face never induced an attack.

Neurological examination was entirely negative except for the demonstration of a trigger zone in the left tonsillar fossa, pressure upon which caused severe paroxysm of pain in this region, which radiated upwards into the left ear. Operation for glossopharyngeal neuralgia was advised but refused.

She returned to the hospital June 29, 1927, with the glossopharyngeal neuralgia still present and, in addition, typical left trigeminal neuralgia involving the first and second branches. In February, 1927, she had developed a severe head cold and on attempting to blow her nose she developed an extreme excruciating pain which started in the left side of the nose about midway between the external nares and inner canthus of the left eye, extended up over the eyebrow to a point about two inches within the hairline of the left side of the head. This was of only a moment's duration. Subsequent to this she developed pain in the same region whenever she blew her nose, bit hard, or washed her face, or touched the upper lip or left side of nose. Firm pressure was less provocative of pain than a very light touch. Talking or laughing not infrequently induced an attack.

Although eating might precipitate an attack of pain in either the trigeminal or glossopharyngeal areas, it was definitely noted that the fifth nerve pain came when the food touched the lips or cheek or when chewing, while the ninth nerve neuralgia appeared only on attempting to swallow.

Pain in the distribution of the first and second branches of the fifth nerve and in that of the glossopharyngeal also appeared spontaneously. At no time did the pain appear simultaneously in both regions.

Operation was performed October 25, 1930. The sensory root of the fifth and the ninth nerve were divided through a single suboccipital approach. Complete relief of pain was obtained and she has remained free since.

CASE IX.—Bilateral ninth nerve neuralgia and left trigeminal neuralgia. M. F., 300310, female, aged twenty-six. Ten months before the first admission the patient developed typical trigeminal neuralgia, first in the third branch, later involving the second and at times the first. In severe spasms the entire left side of the face seemed to be involved. She had had several alcohol injections elsewhere but without the development of anæsthesia or relief. In some of the attacks the pain seemed to extend not only to the entire half of the face but to the neck, shoulder, and left arm. She was operated upon October 5, 1932, in this clinic, a partial section of the sensory root of the left fifth nerve being made. The ophthalmic portion of the sensory root was definitely demarked from the remaining fibres and was preserved. The motor root was uninjured. She was completely relieved of pain in the second and third divisions and the areas supplied by these fibres were anæsthetic. A few weeks later she developed shooting pains in the left posterior pharynx and tonsillar region. These pains were exactly the same as the trigeminal pains, differing only in location. Later similar attacks of pain were felt on the right posterior part of the tongue and right tonsil region and in addition pains appeared in the first branch distribution of the fifth nerve on the left. She accordingly returned for further study. The neurological examination was negative save for the anæsthesia in the distribution of the second and third branches of the left fifth nerve. She was now having frequent attacks of pain in the left eye and forehead and attacks of exactly similar pain radiating downwards into the throat from the left tonsillar region and posterior pharynx, with the pain at times seeming to radiate to the left shoulder region. Between attacks of pain on the left side she had attacks in the ninth nerve distribution on the right. These pains occurred spontaneously, but were usually initiated by swallowing. Stimulation of the posterior pharynx on either side caused a paroxysm of sharp, shooting, lancinating

pain in the distribution of the ninth nerve on the side stimulated. Sometimes a very light touch on the anterior pillars started up a paroxysm of pain. She was operated upon June 23, 1933, under avertin anæsthesia. Through a "U"-shaped incision just posterior to the left mastoid the skull was opened and the ninth nerve divided at the jugular foramen. The sensory root of the fifth nerve was then exposed and found to be decidedly fibrous. It was completely divided. A "U"-shaped incision was then made on the right side and the ninth nerve divided at the jugular foramen. Convalescence was uneventful. There was complete anæsthesia in the distribution of the left fifth nerve and in the distribution of both ninth nerves. There was complete relief of pain.

Case X.—Right glossopharyngeal neuralgia. E. S., 259735, female, aged fifty. She first noticed pain in November of 1930. It was felt in the right side of the throat and was induced by the drinking of either hot or cold liquids. There seemed to be no difference whether it was hot or cold. For the first month only a single stab of pain was felt. Later pains consisted of multiple stabbing pains coming in rapid succession. The attacks lasted about one minute by the watch. They started in the neck and shot up into the throat and posterior pharynx and into the ear. There was no pain in the base of the tongue and it was questionable in the tonsillar region. The pain was usually felt during the day but on a few occasions she had had attacks at night. The pain was generally precipitated by swallowing and no difference was noted between liquid and solid foods. There were two or three periods in which the pain disappeared entirely for a few days. Occasionally pain was felt in pinna of ear. Talking sometimes produced pain and did so during the course of the examination. A section of the right glossopharyngeal nerve intracranially was performed March 4, 1931. She has remained free of pain to date, an interval of three years and nine months.

Case XI.—Right glossopharyngeal neuralgia. L. S., 280229, female, aged thirty-six. For a period of seven years she has had attacks of severe pain radiating from the larynx to the ear on the right side. At first the attacks occurred every two or three months. Gradually they became more frequent until they occurred twice a week. Each attack lasted about twenty-four hours, occasionally thirty-six to forty-eight hours. During the attack the pain was continuous. It started as a minor pain on the right side of the larynx radiating to the ear, then slowly increased in severity, reaching the maximum in one to two and a half hours. The period of greatest severity might last twenty-four hours, then diminish for one-half to one hour and then cease. During the severe or maximum pain period the pain was felt continuously in the region extending from the larynx to the ear, and in addition there was an ache deep in the ear. During very severe attacks she had felt some pain in the right cheek. She described the severe pain as a sharp, aching pain of great intensity. Touching the right tonsillar region and especially the pharynx lateral and posterior to the tonsillar fossa repeatedly started up characteristic pain of short duration. She stated that the spot touched which was the lateral pharynx at the base of the tonsillar fossa was where the pain generally started. She was decidedly neurotic and it was very difficult to elicit a clear description of the pain. However, she was very certain that it radiated usually from the larynx up to the ear.

This pain was not typical of glossopharyngeal neuralgia inasmuch as the duration of attacks was much longer and the pain was described as a sharp and aching instead of a cutting pain. She insisted, however, that it was very sharp and perhaps the difficulty rested largely in her interpretation of the word "ache." The production of typical pains by stimulating the posterior pharynx was the most conclusive proof that she had glossopharyngeal neuralgia. The attacks were incapacitating and accordingly she was operated upon November 2, 1932, the right glossopharyngeal nerve being sectioned intracranially. She was relieved of pain and has remained free since.

Case XII.—Right glossopharyngeal neuralgia and trigeminal neuralgia of second and third divisions. W. D., 257108, male, aged fifty-five. Admitted to the neurosurgical service January 21, 1931, complaining of pain in the right lower jaw, ear, and neck. This had been present periodically over a period of years. It was described as coming on in

sudden attacks over the right side of the neck, throat, and lower jaw. He likened it to a series of jabs with an ice-pick. He was completely free of pain between attacks. For two weeks prior to admission the pain had increased in frequency and severity, appearing at every attempt to swallow. The pain also seemed to radiate deep into the lower jaw, but was never felt in the skin. While this lower jaw pain suggested the possibility of trigeminal neuralgia, the fact that it was never superficial was against such a diagnosis. A diagnosis of right glossopharyngeal neuralgia and possible trigeminal was made.

January 22, 1931, under avertin anæsthesia, through a unilateral cerebellar approach, an intracranial section of the right ninth nerve was done. His post-operative convalescence was entirely uneventful and he was free from pain, being discharged on his seventh post-operative day.

He remained free from pain until July 3, 1931, at which time he returned to the hospital with pain typical of tic douloureux in all three divisions of the right fifth nerve. This had been present for the past ten days. It was most severe and apparently started in the third branch. There had been no pain in the glossopharyngeal area since section of the ninth nerve. An alcohol injection was made into the third division, following which the patient remained free from pain until March 1, 1932, when it again recurred, but only in the second and third divisions. At this time it had become so severe and frequent that he was unable to eat or sleep. He was again admitted to the hospital March 29, 1932, at which time a subtotal resection of the sensory root of the right gasserian ganglion was performed, the ophthalmic fibres being preserved. His post-operative convalescence was entirely uneventful, he was completely free from pain and was discharged on his fifth post-operative day. There has been no return of pain since.

Case XIII.—Right glossopharyngeal neuralgia. N. V., 314011, female, aged fifty-six. Admitted to the neurosurgical clinic May 21, 1933, complaining of pain in the right side of the neck radiating to right ear, of three weeks' duration. It was described as spasmodic attacks of excruciatingly sharp pain beginning in the right side of the neck and radiating upward toward the ear. They were of one to several minutes' duration. At first they occurred every other day, but shortly recurred many times a day. An attack was commonly precipitated by swallowing, less often by talking, but they also occurred spontaneously. They were of such severity that the patient cried out and was afraid to swallow for fear of initiating an attack. Pressure on the right ear occasionally induced an attack.

Neurological examination was negative except for a trigger zone in the right posterior pharynx. Touching this spot with a cotton applicator produced an extremely severe attack which lasted for several minutes. Seldom have I seen a patient with such excruciating pain.

Operation was performed May 23, 1933. Through a unilateral cerebellar approach, intracranial section of the right ninth nerve was done. Her post-operative convalescence was entirely uneventful and she was discharged on the eighth post-operative day completely relieved of pain. A post-operative neurological check-up showed analgesia of the right posterior third of the tongue, right anterior and posterior tonsillar pillars and lateralward toward the buccal mucosa for about three-eighths of an inch. Posterior portion of the under surface of the soft palate was analgesic, posterior pharyngeal wall up to the level of the floor of the nose was analgesic. In all regions the analgesic area ended in the mid-line. Gag reflex was maintained on both sides. Microscopical examination of portion of ninth nerve with a few ganglion cells attached showed no pathology.

Case XIV.—Left glossopharyngeal neuralgia. E. R., 159026, female, aged sixty-three. Admitted to the neurosurgical service December 2, 1933, complaining of severe pain in the left side of throat of four years' duration. This was variously described as sharp, shooting, and stabbing. It occurred in paroxysms, beginning in the right side of the neck, apparently in the tonsillar fossa and radiated upwards towards the ear and downwards into the throat. There have been periods of several weeks of freedom. The pain was often initiated by swallowing and talking but had occurred spontaneously. Re-

cently the attacks had become much more severe and occurred many times a day. The physical and neurological examinations were essentially negative.

December 7, 1933, through a unilateral cerebellar approach, intracranial section of the left ninth nerve was done. She was discharged on her thirteenth post-operative day, entirely relieved of pain. The regions supplied by the left ninth nerve were completely anæsthetic, but the patient was not conscious of this loss. She has remained free from pain.

Treatment.—In this country intracranial section of the glossopharyngeal nerve has been almost universally accepted, but in Europe the extracranial approach is favored. We believe the intracranial approach is as safe as the extracranial one. It is certainly much simpler, more quickly performed, and is the only positive assurance against recurrence. In the extracranial approach the vagus nerve was commonly injured, while with the intracranial approach there is scarcely any danger of injuring the vagus since the ninth nerve is distinctly separated from it.

We have performed the operation under both local and general anæsthesia. If local cannot be used because of the nervous condition of the patient, avertin seems to be preferable to ether or nitrous oxide since both of the latter increase intracranial pressure and make elevation of the cerebellum somewhat more difficult.

The incision is "U"-shaped with comparatively short arms and is centred about midway between the mastoid and the mid-line posteriorly. A defect in the skull about three and one-half centimetres in diameter is sufficient. A "U"-shaped incision is made in the dura and the cerebellum gently lifted with a Frazier lighted retractor. The arachnoid at the lateral margin of the cisterna magna is incised, allowing the escape of cerebrospinal fluid. The cerebellum is then easily elevated, disclosing the jugular foramen with the ninth, tenth, and eleventh nerves entering it. The ninth nerve lies anterior to the vagus and passes through a separate dural foramen. It can be divided with a sharp right angle knife. The dura is usually closed with a few fine silk sutures. In our series no complications have arisen from the operation.

SUMMARY

A survey of the literature on glossopharyngeal neuralgia has been made and fourteen personally observed cases are here reported. Twelve of these were operated upon. All cases, with one exception, were unilateral. Five cases were apparently unique in that there were both glossopharyngeal neuralgia and trigeminal neuralgia on the same side. In two of these the trigeminal neuralgia involved only the first and second divisions. Of the other three, one had pain in the third, one in the second and third, and one in all three divisions. No mistake in diagnosis seemed possible in any of these, certainly not in those with pain only in the first and second divisions. The patient with bilateral glossopharyngeal neuralgia also had trigeminal neuralgia in all three divisions on one side. The results of operation were entirely satisfactory, all patients being permanently relieved. None noticed the loss of sensa-

tion in the distribution of the ninth nerve. I believe that intracranial section of the ninth nerve is the procedure of choice.

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DILATATIONS OF THE CAVUM SEPTI PELLUCIDI AND CAVUM VERGÆ

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Introduction and History.—In the past few years several excellent articles have appeared on this subject. The authors were concerned mainly with the anatomical and surgical aspects of the condition. Because of the relative rarity of dilatations of the septum pellucidum and the cavum vergæ, and because of the confusions that might exist in interpreting encephalograms in patients with solid tumors of this structure, we wish to report four cases and discuss the Röntgen diagnosis of these conditions.

In 1928, we were faced with the problem of explaining what was thought to be an "unusually large third ventricle" in a patient referred to us by Dr. C. H. Frazier for encephalography. We did not recognize the nature of the anomaly until later after consultation with Dr. Francis C. Grant, who told us that it was a fifth ventricle. In 1930, the same type of fifth ventricle abnormality was visualized in another patient. It was not until 1931, after reading Dandy's[5] excellent report on the subject, that we were impressed with the importance of dilatations of the septum pellucidum. Since then we have seen one other patient in our department and the films of another studied in the Episcopal Hospital.

According to Dandy,[5] the cavum septi pellucidi or fifth ventricle has been known at least since the time of Sylvius. The ventriculus fornicus, cavum vergæ, was not described until 1851. It is probable that the first description was written several years before this time. Dandy, in reviewing the claims to priority by Verga and by Ferrario, pointed out that while Verga might have been the first to discover the ventricle, Ferrario was the first to publish his observations, and in reality the sixth ventricle should have been called Ferrario's ventricle instead of the cavum vergæ. The nomenclature is not uniform, however, the sixth ventricle having been known as the ventricle of Strambio, ventriculis triangularis, and the ventriculus fornicus.

Anatomical Considerations.—Several years ago, Thompson,[13] in studying the cavum septi pellucidi in the lower animals and man, came to the conclusion that the best evidence favored the opinion that the cavum arose by interstitial cleavage in the lamina terminalis. He stated that the cleavage occurred in the lamina terminalis before the development of the genu and the rostrum of the corpus callosum. Furthermore, Thompson pointed out that the development of the rostrum of the corpus callosum prevented subsequent communication between the cavity and the intercerebral fissure. Other men have been of the

opinion that the cavum septi pellucidi was a portion of the intercerebral fissure which was shut off by the concrescence of the cerebral hemispheres and the development of the various commissures. It may have been that the cavum developed as a cleft in the previously solid septum as the result of the operation of certain mechanical strains to which it had been subjected by the developing commissures and fornix. Dart[7] believed that the cavum septi pellucidi was absent in many of the lower animals and that when it was present it was closed. Thompson conclusively demonstrated the presence of the septum in dogs, cats, and monkeys, and was able to demonstrate a cavum in some of them.

According to Portier and Charpy,[11] Verga's ventricle develops in the fourth or fifth month of intra-uterine life and is normally present in most newborn infants. It rarely persists in adults, however, as it becomes obliterated early in life. Backman[3] studied a series of 234 brains which showed abnormal findings in the region of the septum lucidum, and found the cavum vergæ in only a few specimens. He felt that while the cavum vergæ was present early in life, the cavum septi pellucidi grew backward and enlarged at the expense of the cavum vergæ and caused its obliteration. VanWagenen and Aird,[14] however, found dilatation of the cavity of the septum lucidum in 60 per cent. of the brains they examined at autopsy. The wide difference in the figures might have been due to the fact that VanWagenen and Aird examined fresh specimens whereas Backman's specimens had mostly been preserved. Shimazono[12] demonstrated that this might have been due to the fixing solution.

Besides being dilated, the septum pellucidum might also be partially or entirely destroyed. Dandy and Blackfan[6] were probably the first to call attention to destruction of the septum. Alexander and Suh[2] described similar findings in three infants in whom it was associated with hydrocephalus. Hochstetter[8] believed that the deficiency of the septum was due to the continuation and exaggeration of the physiological involution of the *anlage* of the septum. Backman also described these septal defects in patients with hydrocephalus.

In the normal brain the corpus callosum defines the anterior, posterior, and superior limits of the fifth and sixth ventricles. The cavum septi pellucidi is bordered anteriorly by the genu of the corpus callosum, posteriorly by the anterior limb of the fornix, superiorly by the body of the corpus callosum, inferiorly by the rostrum of the corpus callosum, and laterally by the layers of the septum lucidum. The cavum vergæ is bordered anteriorly by the anterior limb of the fornix, posteriorly by the splenium of the corpus, superiorly by the body of the corpus callosum, and inferiorly by the psalterium and hippocampal commissure. A more complete description of the cavum septi pellucidi and Verga's ventricle may be obtained from Dandy's paper.[5]

VanWagenen and Aird have so thoroughly reviewed the literature on the source and nature of the fluid within the cavum septi pellucidi and cavum vergæ that little can be added.[14] The question as to whether or not there

exist normal paths of communication between the septal ventricles and the lateral ventricles has been debated by many men. Dandy referred to the valve of Vieussens, and the foramen of Mihalkowski which, in the opinion of Petit, Tedmann, and others, were normal foramina. Verga and others believed that they were artificial openings. Dandy also believed that they were artificial because their borders were ragged and shreds of tissue could be seen hanging from the sides of the orifices. VanWagenen and Aird reported 60 per cent. of the fresh brains they studied had septal dilatations. If this represents the true percentage in a large series of brains it would seem plausible that no communication exists normally between the septal cavities and the other ventricles surrounding them. If such communications do exist normally, many more should have been visualized by encephalography than have been reported. In our department alone we have examined the encephalograms of 500 individuals, yet we have seen only three patients with dilatations present in the septum lucidum. We believe, therefore, that these fenestra are artificial and are dependent upon the points of greatest thinning of the septal wall.

REVIEW OF THE CASES DESCRIBED IN THE LITERATURE

Dandy gave credit to Verga, Ferrario, Sangalli, and others for the patients they had reported in the literature in the latter part of the nineteenth century.[5] The credit for the first more recent work upon dilatations within the septum pellucidum must be given to Meyer,[10] who published his excellent article in 1930. We must also give Meyer the credit for reporting the first patient in whom an encephalogram had been performed and a diagnosis arrived at on the basis of the Röntgen findings. His report contained the clinical records of five patients with dilatations of the cavum septi pellucidi and cavum vergæ.

In 1931, Dandy[5] published his description of congenital cerebral cysts and added reports of two more patients. The latest and most complete article upon the subject was recently published by VanWagenen and Aird.[14] They were able to find fifteen patients with septal dilatations. Of this group, however, only five presented abnormal neurological pictures during life. Nine of the patients had been examined at autopsy and the dilatations of the fifth and sixth ventricles were merely incidental findings.

CASE REPORTS

CASE I.—M. S., No. 14726, a white male, aged fifteen years, referred from the neurosurgical service of Dr. C. H. Frazier, University of Pennsylvania Hospital, had been perfectly well until two years prior to his admission. At that time, the boy fell twenty feet, landing on his head. He was unconscious for several minutes and soon began to complain of a severe headache. He was hospitalized because of the nature of his injury and remained in the hospital for over one month. During his stay at the hospital, the child frequently complained of severe headaches, nausea and vomiting. These symptoms had appeared several days after his injury and within several weeks there became associated with them fainting sensations, vertigo and generalized convulsions. The convulsive seizures were usually preceded by a feeling of weakness and vertigo and within just a few seconds the child lost consciousness. These attacks lasted but a few minutes and

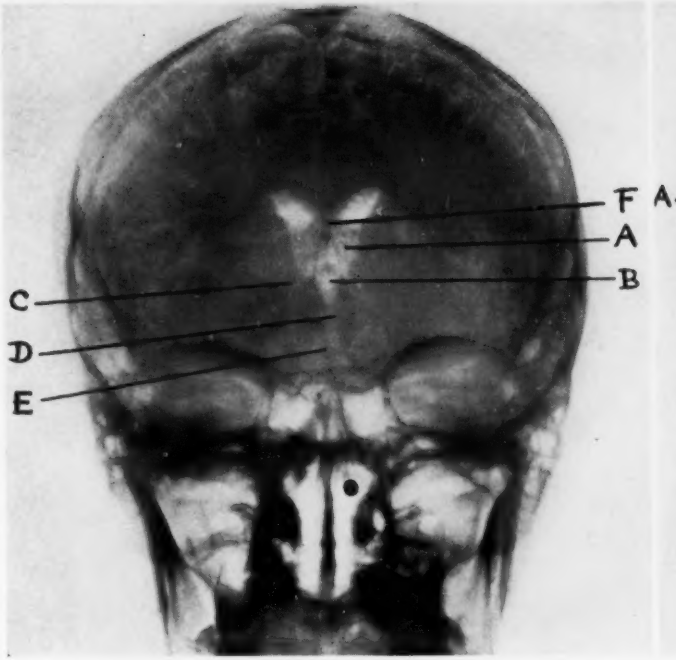

FIG. 1.

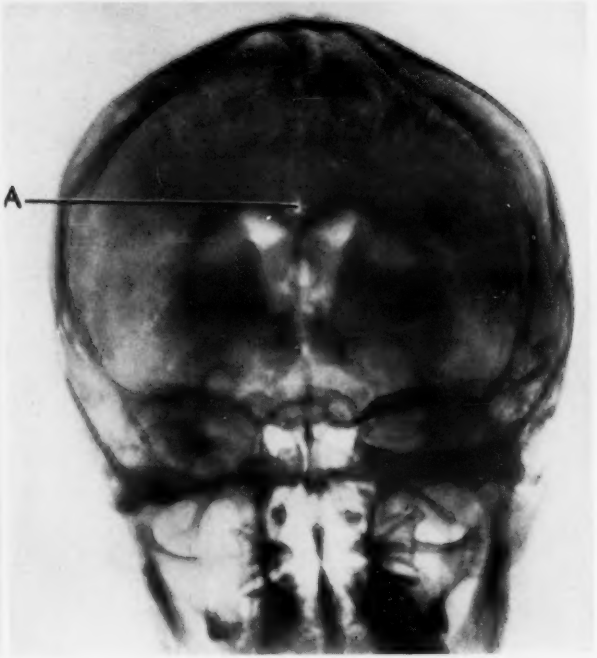

FIG. 2.

FIG. 1.—Anteroposterior view of a normal encephalogram showing normal size of the ventricles with no mid-line shift and the subarachnoid markings distributed over the cortex. The lateral ventricles are seen at A. The expanding anterior horns cannot be seen very well except on the original films. The third ventricle is seen at B. The triangular subarachnoid air of the lateral cerebrocortical pathways is seen at C. The aqueduct of Sylvius is seen at D. The triangular fourth ventricle is seen at E. There is no visualization of the sagittal subarachnoid pathways. The septum pellucidum is seen at F.

FIG. 2.—Postero-anterior projection of a normal encephalogram. Note the subarachnoid distribution of air. The ventricles are in the mid-line and there is no shift. Note that the posterior horns are symmetrical. Note the sagittal subarachnoid pathway which is the one over the corpus callosum seen at A.

there was nothing to indicate that the child had lost sphincteric control or bitten his tongue. Following his attack he always seemed well oriented but tired. There was nothing in the description of the child's seizures that might have established them as being Jacksonian in nature.

The child's past medical history seemed unimportant. He had suffered attacks of tonsillitis, and had mumps and acute appendicitis for which he had been operated upon eight years before the onset of the convulsive seizures. The family history contained nothing remarkable.

The most striking feature about the child was the marked mental impairment. His mentality was that of an eight-year-old child. He was dull and had the physical features of constitutional inferiority. The boy's muscular coördination, station and gait were

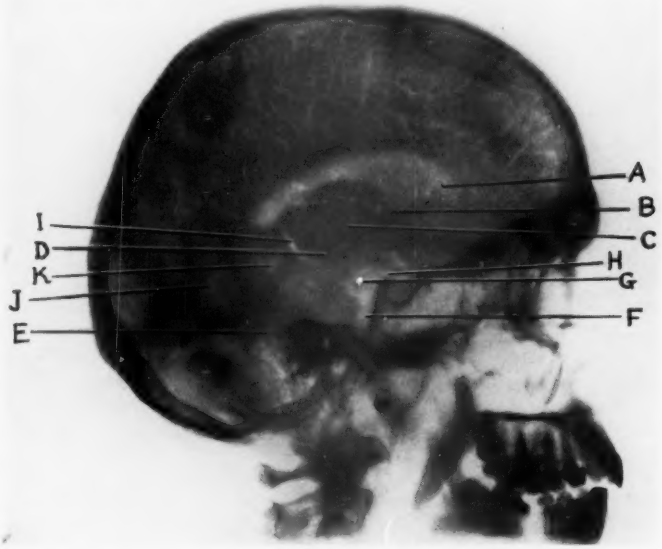

FIG. 3.—Lateral view of same patient as Fig. 1, showing normal subarachnoid markings over the anterior two-thirds of the cortex of the brain. The lateral ventricles are seen superimposed at A. The foramen of Monro is seen at B, the third ventricle at C, the aqueduct of Sylvius at D, the fourth ventricle at E, the cisterna pontis at F, the interpeduncularis at G, the chiasmatis at H, the lateral internal subarachnoid pathways at I, the cerebrocortical pathways at J, the ambiens at K.

normal. There were no changes in either objective or subjective sensation. The cranial nerves were unaffected and there were no changes observed in the eyegrounds or visual fields. There was a mild hypochromic anæmia with no unusual white blood-cell picture. Urine, spinal fluid and blood studies were normal. Blood and spinal Wassermann reactions were also normal.

Routine röntgen examination of the head, November 7, 1928. There was no röntgen evidence of increased intracranial pressure or any other abnormality.

Encephalographical examination, November 10, 1928. The Röntgen study of the head showed the typical appearance of the cavum septi pellucidi. The ventricular system was within normal limits of size and there were no enlargements of the subarachnoid pathways (Figs. 7, 8 and 9).

CASE II.—E. C., No. 467, a white male, fifty-two years of age, referred from the neurosurgical service of Dr. C. H. Frazier, University of Pennsylvania Hospital, had been well until five months before his admission to the hospital for study. Once, twenty-four years prior to the onset of his present illness, the patient had a severe head

injury which was followed by unconsciousness for twenty-four hours. Since that time, however, he had been in apparent good health. The present illness started suddenly while the patient was at work, when he fell to the ground momentarily unconscious. Within a few minutes he was able to resume work. Several weeks later he had his second attack, which was of a more severe nature. The second attack started during the night, when he awoke and complained of a terrible headache. In a few moments he got out of bed and fell. The patient was able to move with help but it was noticed that he dragged his feet and made gripping motions with his left hand. The following morning he was well again with the exception that he hesitated slightly while walking. Two weeks after this attack he suddenly became jocose, irrational, complained of headache and peculiar sensations in his left hand, and had a peculiar "drunken" gait. After this attack the patient remained relatively well for three months. During this interval, however, he had developed a slight speech defect and a tendency toward a euphoric mental

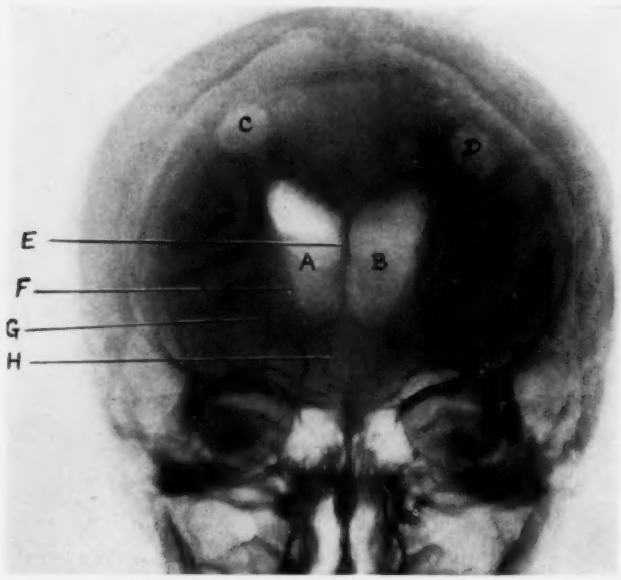

FIG. 4.—Postero-anterior ventriculogram with patient lying on his back. A and B, lateral ventricles; C and D, trephine openings; E, septum pellucidum; F, side of the body of the ventricle; G, anterior horn; H, third ventricle.

state. The last attack, and the most severe one, occurred two weeks before admission to the University Hospital. For no apparent reason the patient suddenly heard buzzing noises in both ears and fell down. He was well oriented and mentally clear but was unable to arise because of generalized muscular weakness. Within several days he had regained some of his muscular power but was left with a slight paresis of his entire right side and definite diplopia.

The past medical history was negative with the exception of the cranial injury reported above. His family history seemed to be unimportant also. The patient confessed to having been a heavy drinker of fermented liquors for many years.

The interest centred about the patient's neurological examination. He was too weak to stand and was extremely dizzy in the erect position. His speech was slurred and slow with occasional omission of entire syllables. There were no involuntary muscle movements. His subjective sensation was normal with the exception of some decreased sensation over the right half of the face. Objectively, his sensation was normal. The patient showed a marked degree of dysdiakokinesia in both upper extremities which was

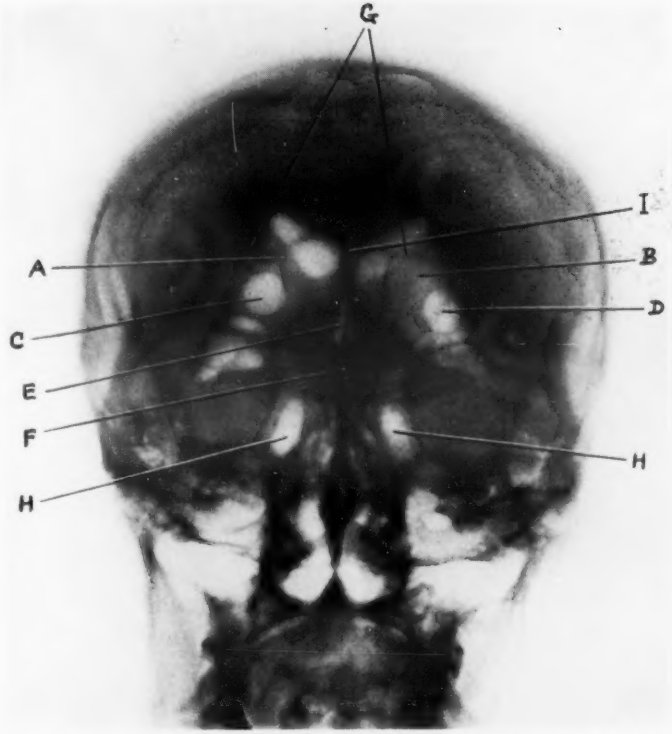

FIG. 5.—Normal ventriculogram. In the anteroposterior view, A denotes the lateral ventricle; B, lateral ventricle; C and D, trephine openings; E, third ventricle; F, aqueduct of Sylvius; G, superimposed frontal sinuses on the ventricular system; H, ethmoidal cells; I, septum pellucidum.

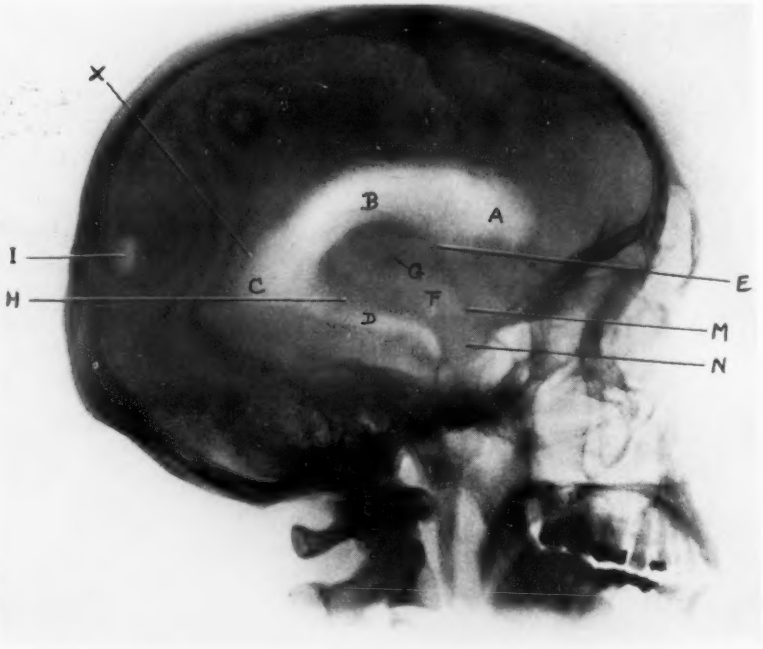

FIG. 6.—Lateral ventriculogram with patient lying on right side. A, anterior horn; B, body of the ventricle; C, posterior horn; D, inferior horn; E, foramen of Monro; F, third ventricle; G, middle commissure; H, aqueduct of Sylvius; I, trephine opening; M, anterior projection of third ventricle; N, pituitary fossa; X, obtuse angle at the junction of the posterior horn and body of the ventricle.

more marked in the right hand. The right arm was spastic and weak. The patient's pupils were normal but the eyes showed a slight nystagmus with the quick component to the right. Hearing was slightly impaired on both sides. There was an uncertain Babinski in the right foot and none in the left. The eyegrounds showed slight tortuosity of the vessels and the visual fields showed a bilateral homonymous cutting in the left lower quadrant. All of the special laboratory studies were essentially negative. Red and white cell counts of the blood were normal. Blood chemistry and urine analyses were also negative. Blood Wassermann, spinal fluid Wassermann, protein, and gold curves revealed nothing of importance. The Barany examinations suggested the presence of a supratentorial lesion.

Routine röntgen examination of the head, April 22, 1930. There was no röntgen evidence of increased intracranial pressure or any other abnormality.

Encephalographic examination, April 25, 1930. The röntgen study of the head

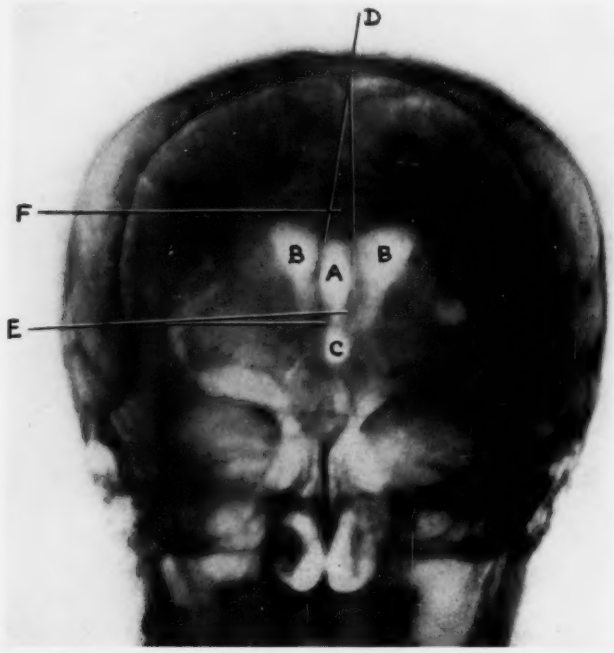

FIG. 7.—(Case I.) Postero-anterior view. The fifth ventricle is in the mid-line between the lateral ventricles. The fifth ventricle is seen at A; the lateral ventricles at B; the third ventricle at C. The upper attachments of the leaves of the septum pellucidum are seen at D and the lower at E. The floors of the bodies of the lateral ventricles are not on the same level. Mid-line sagittal pathway is seen at F.

showed a typical appearance of a cavum septi pellucidi. The remaining ventricular system was top normal in size (Fig. 10).

CASE III.—B. K., No. 27946, a white male, twenty-four years of age, referred from the neurosurgical service of Dr. C. H. Frazier, University of Pennsylvania Hospital, had been in perfect health until two years prior to his admission to the hospital when he began to complain of spells of unconsciousness. At that time the patient suddenly became unconscious and suffered his first convulsive seizure. He had been talking at the time and without any warning he lost consciousness. This sudden onset characterized the beginning of all his attacks which had occurred at bi-monthly intervals. He was never aware of an impending convulsive seizure and knew nothing of them until after regaining consciousness. The attacks usually lasted from thirty to forty-five minutes.

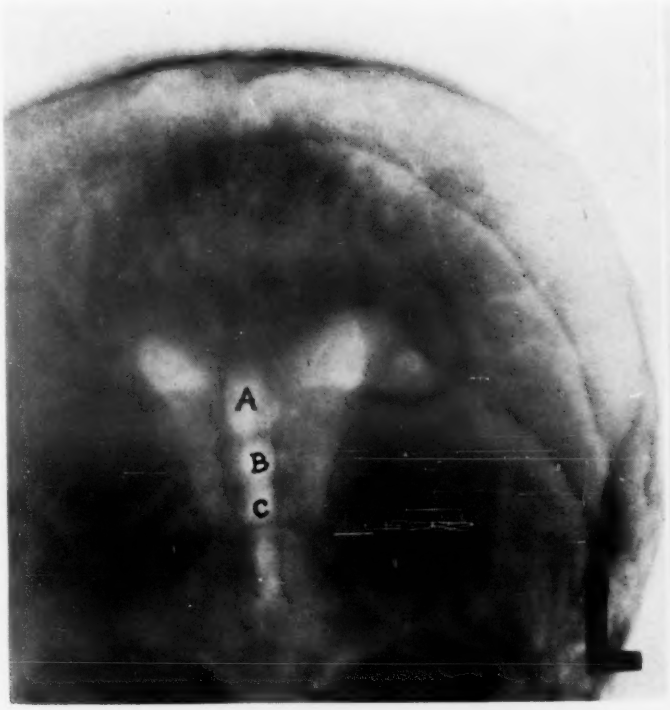

FIG. 8.

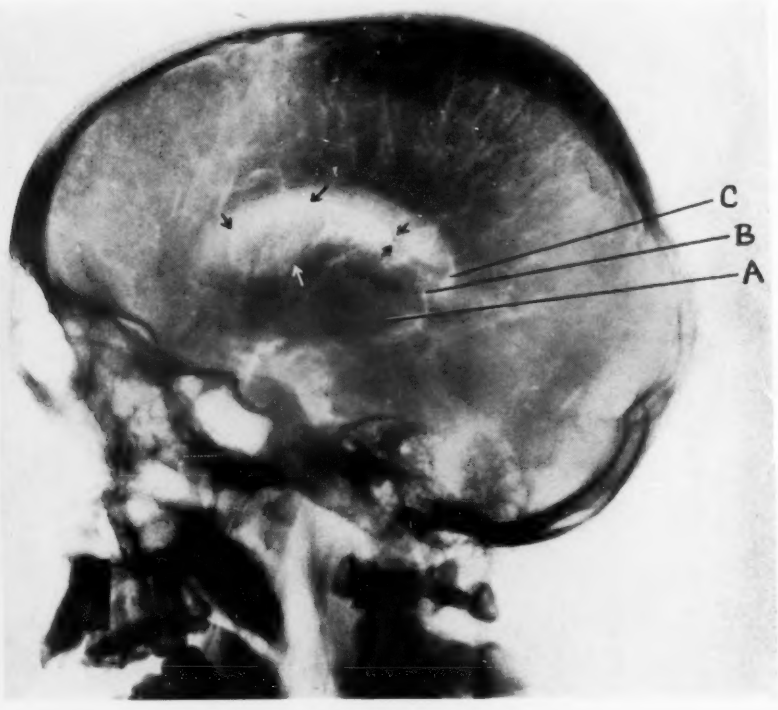

FIG. 9.

FIG. 8.—(Case I.) The dilated cavum septi pellucidi is seen at A, superimposed upon the third ventricle, C; aqueduct of Sylvius, B.

FIG. 9.—(Case I.) Lateral view of the same case as Fig. 7. The cavum septi pellucidi is superimposed upon the lateral ventricles. There is a dense portion of the air shadow outlined by the arrows. Note the undine shape of the shadow. The aqueduct of Sylvius opens into the third ventricle at A. Lateral subarachnoid pathways are seen at B, and cisterna ambiens at C. The illustration has been retouched.

There was nothing characteristic. They always started without warning and the convulsive seizures were always generalized and apparently never focal. The patient never bit his tongue during the convulsion nor did he lose sphincteric control. He usually was very weak and tired after an attack, dropping off into a deep sleep for several hours.

The past medical history was unimportant. There was no history of birth trauma and he had had the usual chickenpox, mumps and whooping cough early in life. The family history was also unimportant.

The patient was an unusually bright young man who held a responsible position and was being embarrassed as the result of his malady. The most careful physical and neurological examinations were negative. His routine blood studies were normal. Blood Wassermann, spinal fluid Wassermann, protein, and gold curves were also normal. The patient's eyegrounds and visual fields revealed nothing abnormal.

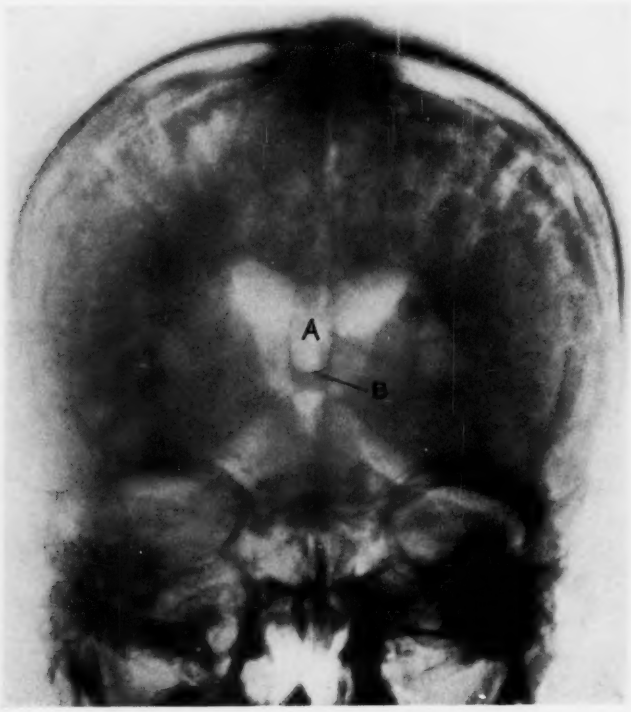

FIG. 10.—(Case II.) Cavum septi pellucidi is seen at A. Note fluid level at B.

Routine röntgen examination of the head, November 7, 1933. There was no röntgen evidence of increased intracranial pressure or any other abnormality.

Encephalographic examination, November 10, 1933. The röntgen study of the head revealed a typical dilatation of the cavum septi pellucidi. The ventricular system seemed slightly enlarged and the subarachnoid pathways were also slightly enlarged indicating brain atrophy probably due to a preëxisting internal and external hydrocephalus (Figs. 11, 12, 13, 14 and 15).

CASE IV.—W. E., a white male, forty-four years of age, referred from the neurological service of Dr. Samuel B. Hadden, Episcopal Hospital, was brought into the hospital in deep coma. With the exception of one day two years prior to his present illness, the patient had been in good health until ten hours before his admission for study. Two years ago he felt weak and drowsy but in twenty-four hours he was able to resume his

FIG. 11.—(Case III.) Anteroposterior view, showing cavum septi pellucidi at A, slightly dilated lateral ventricles at B. The subarachnoid markings are slightly dilated. Note the fluid level in the septal cavity at C.

FIG. 12.—(Case III.) Postero-anterior view.

duties as a loom worker in a factory. There had been no recurrences of these symptoms since that time. The night prior to his admission, however, his wife noticed that he

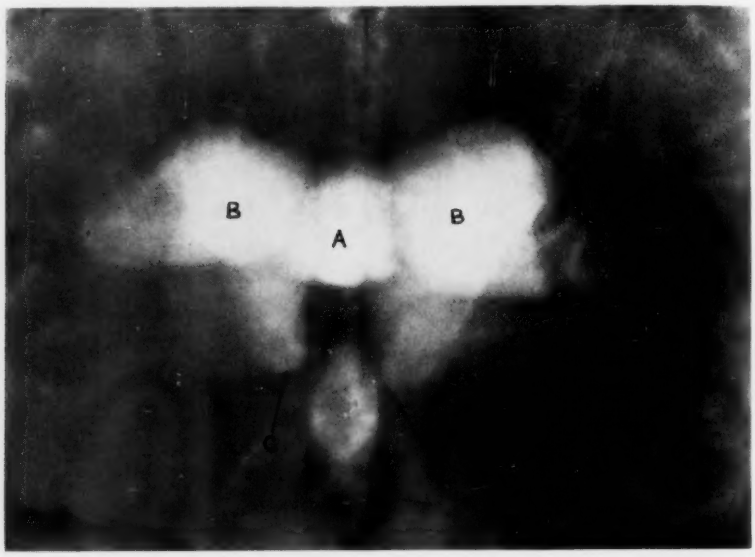

FIG. 13.—(Case III.) Enlarged view to show detail of relations of septal cavity. Note the difference in the level of the floors of the bodies of the lateral ventricles. A, cavum septi pellucidi; B, lateral ventricles; C, floor of body of lateral ventricles.

had partially lost consciousness. She tried to talk with him but he seemed very dull mentally and when he tried to answer his speech was slurred and thick, making it im-

FIG. 14.—(Case III.) Lateral view of same patient as in Fig. 11. Note large undine-shaped cavum septi pellucidi.

possible to understand him. Within a short time he lapsed into a deep slumber from which he could not be aroused. There were no convulsive twitches at the time.

On admission to the hospital, the patient was stuporous. Supra-orbital pressure failed to arouse him. The pupils reacted to both direct and indirect light and there was a suggestion of conjugate deviation to the left. The right nasolabial fold was less prominent than the left. There were no perceptible reflex or muscle-tone changes in any of the extremities at that time. Examination the next day found the patient much improved. He could be made to answer questions with difficulty. The neurological survey showed no change with the exception that slight nystagmus was noticed when the patient looked to the extreme right or left.

The patient continued to improve without specific therapy and in about ten days was well enough to give a satisfactory account of his feelings prior to his acute illness. He stated that he had been having severe bilateral frontal headaches for the last six months which lasted from one to two hours daily. Once or twice a week the headaches were accompanied by bilateral tinnitus.

Routine blood and urine analyses were negative. Blood serology was negative on

FIG. 15.—Enlarged view of cavum septi pellucidi shown in Fig. 14.

four occasions and was reported as "plus 4" once. Lumbar puncture revealed normal pressure, normal cell count, normal protein, and the colloidal gold and Wassermann examinations were negative.

Routine Röntgen examination of the head, October 2, 1934. There was no Röntgen evidence of increased intracranial pressure, or any other abnormality.

Encephalographical examination, October 5, 1934. (Report by Dr. Lowry Allen of the Episcopal Hospital.) The Röntgen study of the head revealed what was thought to be a cavum septi pellucidi and cavum vergæ. The ventricular system was within normal limits of size. The subarachnoid pathways were slightly increased in size, suggesting some cortical atrophy due to a preëxisting hydrocephalus (Figs. 16, 17, 18 and 19).

Cases Reported with Congenital Cysts of the Septum Lucidum

Author	Number of Cases
Meyer (1930)	5
Dandy (1931)	2
VanWagenen and Aird (1934)	5
Pendergrass and Hodes (1934)	4

FIG. 16.—(Case IV.) Cavum septi pellucidi and cavum vergæ are seen at A. Note lateral extension at B.

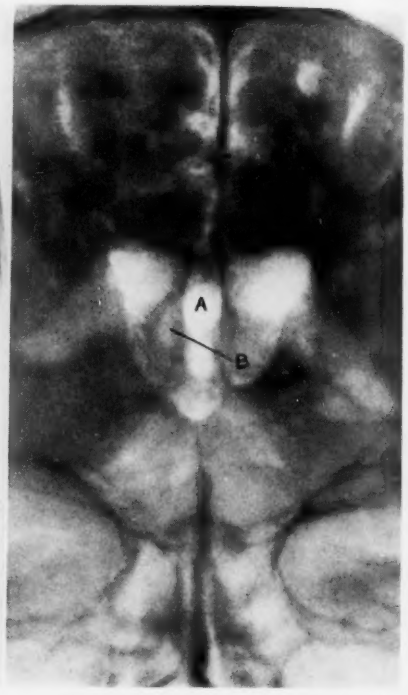

FIG. 17.—(Case IV.) Enlarged view of cavum septi pellucidi and cavum vergæ shown in Fig. 16 at A; lateral extension at B.

FIG. 18.—(Case IV.) Same patient as Fig. 16, lateral view. Note hour-glass shape of cavum septi pellucidi at A and cavum vergæ at B.

Comment on Clinical Findings.—All three of the patients reported showed a quantitative intellectual reduction with inability to concentrate. Of these three patients two indicated a tendency to be euphoric and jocose. All suffered periods of complete loss of consciousness at irregular intervals. In two the attacks of unconsciousness were associated with generalized clonic convulsions. Whether or not the speech defect noted in two of them was the result of their depressed mental condition or the result of a true motor aphasia could not be determined. Incomplete motor weakness of the extremities was present in one of the series. Another presented a questionable facial weakness on one occasion only. Two patients complained of severe headache and one complained of severe buzzing and roaring in his ears prior to each attack. Loss of deep sensation and ataxia were referred

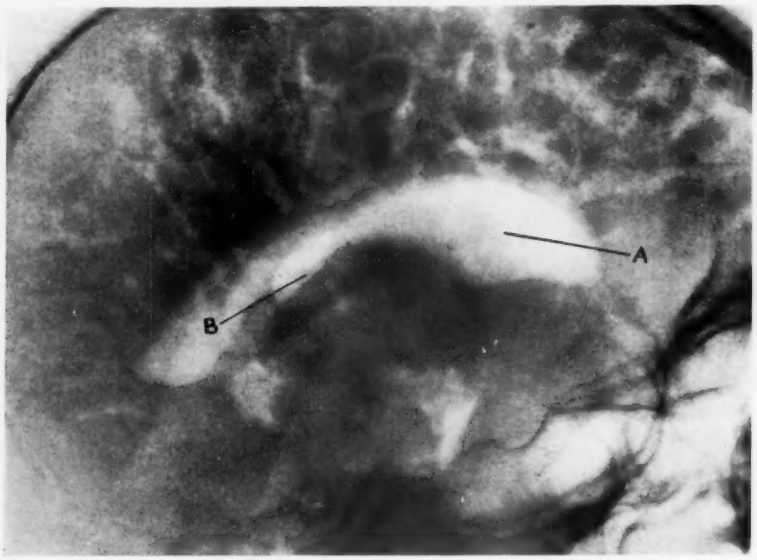

FIG. 19.—(Case IV.) Enlarged view of cavum septi pellucidi at A and cavum vergæ at B, shown in Fig. 18.

to in the patient who had developed incomplete motor weakness. Only one revealed a change in the visual fields which seemed limited to the lower quadrant in each eye. Thus it was evident that the clinical picture differed from that seen in lesions of the corpus callosum in that somnolence and motor apraxia were lacking.

Röntgen Considerations.—Since the advent of cerebral pneumography the Röntgen diagnosis of dilatations of the septal cavities has been made with increasing frequency. When these structures communicate with the lateral or third ventricles the Röntgen diagnosis is relatively easy, but when they do not communicate this condition must be differentiated, if possible, from the other mid-line lesions.

A number of authors have reported that the cavum septi pellucidi and the cavum vergæ occur frequently. We have not been able to confirm this opinion by either ventriculography or encephalography. A very small, slit-like cavity

could easily be overlooked in the films, however, if the cavum did not communicate and the dilatation was not very large, because of failure to evaluate slight differences in the width of the septum lucidum from above downward. This of necessity requires that the head be absolutely straight in the postero-anterior and anteroposterior positions.

In the routine Röntgen examination of the head no evidence of increased intracranial pressure is found in the communicating type but may be found in the non-communicating type.

Encephalographic and Ventriculographic Findings Arbitrarily Regarded as Normal.—It is not in the province of this paper to describe the various normal appearances of these two procedures. Brief pertinent facts will be mentioned and illustrated. The difference in the size of the ventricular system in the two methods of examination is due to the fact that in encephalography the focal film distance is forty-four inches whereas in ventriculography it is thirty inches, the ventricles in the latter procedure being large due to distortion.

The encephalographic findings are illustrated in Fig. 1. The sagittal subarachnoid pathway is visualized in Fig. 2. The lateral projection is seen in Fig. 3. The ventriculographic findings are shown better in the illustrations because of the absence of the subarachnoid markings. The postero-anterior projection is seen in Fig. 4. The anteroposterior projection is seen in Fig. 5. The lateral projection is seen in Fig. 6.

The septum pellucidum can be seen in the sagittal projections and not in the lateral view. It appears on the anterior röntgenogram as a thin septum between the lateral ventricles and is uniform in width except at its upper and lower boundaries where it tends to widen slightly. In our ventriculograms the normal width is from two to three millimetres, whereas in encephalograms its width varies from 1.5 to two millimetres.

Any widening in the septum lucidum in a head that is symmetrically placed should arouse one's suspicion of a dilated cavum septi pellucidi or cavum vergæ. One must be very careful in studying the septum as slight changes are likely to escape notice due to the obscuration caused by the filled ventricles. Slight changes in the septum lucidum from before backward can be determined only by noticing variations in the density of the air shadow in the ventricles close to the septum.

Dandy,[5] and VanWagenen and Aird[14] have described three types of dilatations of the cavum septi pellucidi and the cavum vergæ.

(1) Non-communicating type in which the walls of the cavity are intact.

(2) Communicating type, in which there is an opening into the third or lateral ventricles caused by rupture when the intracystic tension becomes too great.

(3) Acquired or secondary type, as a part of a later developing internal hydrocephalus.

Dandy and Blackfan[6] and Alexander and Suh[2] have described cases with complete and partial destruction of the septum lucidum. For Röntgen con-

siderations we are interested only in the communicating and non-communicating types.

Communicating Type.—This type is easily demonstrated in the röntgenogram after encephalography and ventriculography. Meyer was probably the first to report the röntgenographical findings in a patient with dilatation of the septal cavities.[10] Dandy[5] reported a patient with a non-communicating type which he had made communicate by means of an artificial opening into the closed cyst at operation. Dandy's patient had a ventriculographic study. We have no doubt other cases have been observed and have not been reported.

Cavum Septi Pellucidi.—We have found dilatations of this structure with greater frequency than the cavum vergæ. All of the cases have been

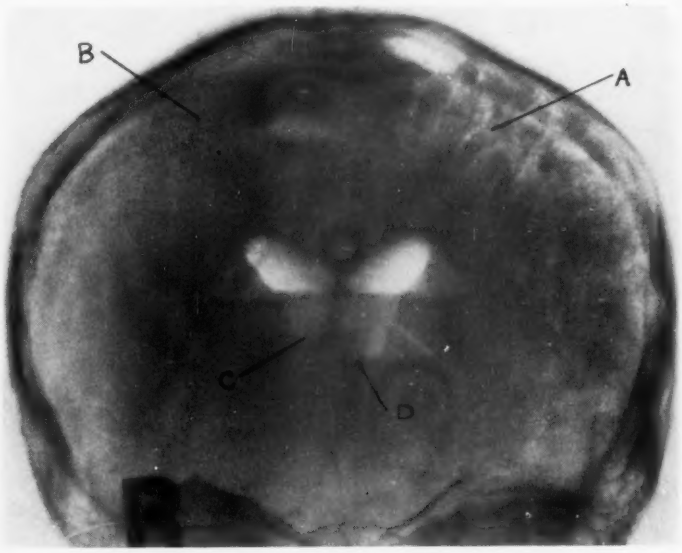

Fig 20.—Postero-anterior view showing cortical markings on the left side at A and absence of cortical markings on the right at B, probably due to arachnoiditis. Note that the ventricular system is in the mid-line but that the floor of the anterior horn and body of the right lateral ventricle, C, is not on the same level as the floor of the left lateral ventricle, D. We realize that the patient in this case is pathological but it brings out to good advantage what is often seen in cases arbitrarily regarded as normal. Is it possible that this patient may have a non-communicating dilated septal cavity?

similar in their röntgen manifestations with the exception of slight variations which will be discussed.

In the postero-anterior view with the head slightly flexed on the chest, the lateral and third ventricles are clearly visualized. The lateral ventricles are separated by an air-containing space. One can visualize the sides of the upper and lower leaves of the septum pellucidum. The roof of the cavity is approximately at the same level as the roof of the inner aspect of the lateral ventricles. The medial and upper walls of the lateral ventricles are sharp and not rounded off. The floor of the cavity may be on the same level with the floor of the body of the lateral ventricles (not the anterior horns). Sometimes the floor of one of the bodies of the lateral ventricles is not on the same level

as the corresponding ventricle on the other side. The significance of this finding is unknown at the present time. (Fig. 20.)

The cavity of the septum pellucidum is ofttimes superimposed or partially so upon the third ventricle and unless one is careful the cavity may be overlooked (Fig. 8).

In the encephalogram the subarachnoid pathways, such as the mid-line subarachnoid (corpus callosum), singulate sulcus, and the lateral subarachnoid pathways are visualized unless the pathways are not drained and fluid displaces the air.

In the anteroposterior views, with the head flexed, the appearance of the cavum is similar to that just described. The third ventricle may be superimposed to a larger extent. In the röntgenograms one sees occasional transverse bands that are due to brain tissue around the aqueduct of Sylvius and the roof of the third ventricle superimposed upon the dilated fifth ventricle.

In the lateral views, the cavum septi pellucidi would be easily overlooked if it were not suspected in the sagittal projection because it is superimposed upon the bodies and anterior horns of the lateral ventricles. It is somewhat the shape of a gourd or undine with the larger diameter anterior and gets smaller as it extends posteriorly until it ends as a blunt point (Figs. 9 and 15). One should be very careful not to mistake a small amount of air in the opposite lateral ventricle for a dilated cavity. This appearance can be very similar (Fig. 34).

The anterior boundary does not extend quite as far forward as the anterior horns of the lateral ventricles. The posterior boundary extends nearly to the beginning of the aqueduct of Sylvius. Sharp definition of this region may be lacking because of the upward curving lateral and subarachnoid pathways (Fig. 9B) and the cisterna ambiens (Fig. 9C) which may overlie it.

Occasionally one visualizes what appears to be a fluid level in the postero-anterior projection. This probably occurs in those cases in which the communication is with the lateral ventricle and not the third ventricle (Fig. 10). This finding occurs only when the films are exposed with the patient in the erect posture. When a fluid level is present in the lower portion of the cavum septi pellucidi, the relationship to the third ventricle can be visualized better in the postero-anterior projection. In the lateral examination the space between the roof of the third ventricle and the fluid level in the cavum is increased (Figs. 11, 12, 13, 14 and 15).

Cavum Vergæ.—We have one patient in whom we believe the cavum vergæ is visualized in addition to the cavum septi pellucidi. We may be entirely wrong in our deductions but the appearances were different from those of the other patients whom we have studied, all of whom were regarded as having dilated fifth ventricles.

In the postero-anterior and anteroposterior views, the same findings described for the cavum septi pellucidi are present. In addition the cavity spreads out more posteriorly and in our patient it extended more to one side than to the other (Figs. 16 and 17).

FIG. 21.

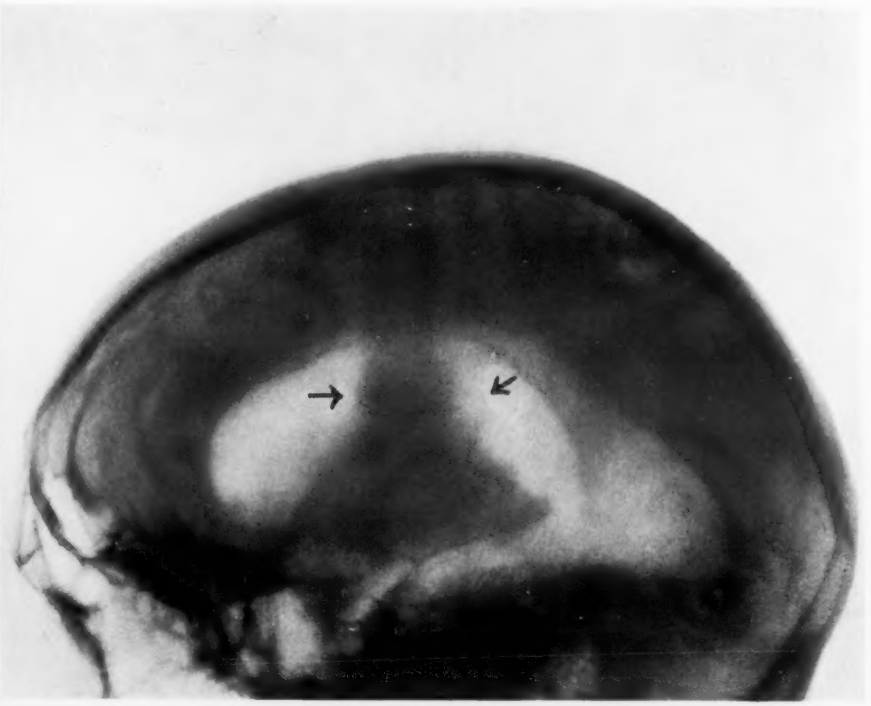

FIG. 22.

FIG. 21.—Ependymoma of the left lateral ventricle. Male, aged thirty, with diplopia and blurred vision in the right eye for three months, increasing visual loss, headache and vomiting for two months, numbness and weakness right leg for one month, numbness and weakness right arm for two weeks. Subjective numbness right side of body, slight spasticity to movements right extremities, weakness left VI nerve, choked disk 6 D. right and left, slight right upper quadrantanopsia. Impression: unlocalized tumor. Ventriculogram: right ventricle tapped, sixty cubic centimetres fluid removed. Left ventricle tapped, ninety cubic centimetres fluid removed. Interventricular communication normal. Fifty cubic centimetres air injected right and left. Postero-anterior view shows huge dilatation of the left lateral ventricle, A, with slight displacement of the mid-line structures to the right and slight encroachment upon the lumen of the right lateral ventricle, B. The third ventricle, C, is slightly displaced to the right. The outline of the tumor is clearly visible in the ventricular system as indicated by the arrows.

FIG. 22.—Same patient as in Fig. 21. Left lateral view shows the outline of the tumor beautifully. Note that the third ventricle is scarcely visible. Diagnosis: ependymoma of the left lateral ventricle. Operation confirmed the diagnosis. The lateral view should differentiate this lesion from a non-communicating dilated septal cavity.

In the lateral view the shape of the posterior portion was also quite different. Instead of the cavity ending in a blunt point, it was somewhat hourglass in shape. The cavum septi pellucidi became smaller as it extended posteriorly then widened again into an oval-shaped cavity which we have interpreted as a dilated cavum vergæ. This structure extends farther posteriorly than the cavum septi pellucidi, the former extending 1.5 centimetres beyond the opening of the third ventricle into the aqueduct of Sylvius (Figs. 18 and 19).

General Röntgen Considerations.—The ventricular system, including the lateral and third ventricles, has been top normal in size. Whether a preëxisting hydrocephalus had been present was uncertain. There was such a wide variation in the size and shape of the ventricles we hesitated to make such a conclusion based upon the size of the ventricles in our series alone.

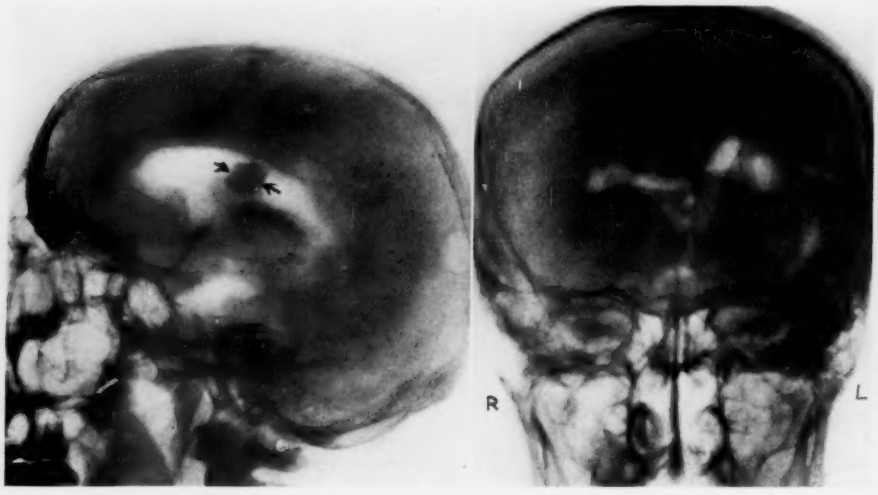

FIG. 23. FIG. 24.

FIG. 23.—Metastatic carcinoma of the left ventricle. Male, aged forty-eight, with pain in head, dizziness, blurred vision and anorexia. Ventriculogram showed a small nodule in the ventricular system due to metastatic carcinoma from bronchogenic carcinoma of the lung, which was confirmed at post-mortem examination.

FIG. 24.—Anteroposterior view shows the roof of the right ventricle is depressed and deformed. The mid-line structures are displaced to the left. Note the absence of subarachnoid markings. Doctor Grant removed an endothelioma of the falx.

The subarachnoid pathways were increased in size in three of the patients, suggesting cortical atrophy. In the other they could be regarded as normal.

Non-communicating Types.—We have no proven cases in our series. The Röntgen signs described below are derived from a study of the Röntgen illustrations of Dandy's and VanWagenen and Aird's patients. The authors do not state, but we would expect to find evidence of increased intracranial pressure in the routine Röntgen examination of the head.

Postero-anterior and anteroposterior views may show the following appearances after ventriculography.

(1) Dilatations of the lateral or third ventricles or all three. This is

probably due to the blocking of the foramina of Monro, or the aqueduct of Sylvius, or both.

(2) Separation of the lateral ventricles due to the mass lesion of the septum lucidum. There may be a rather uniform encroachment upon the mesial sides of both lateral ventricles, or the encroachment may be more on one lateral ventricle than the other.

(3) The third ventricle seems to be depressed slightly.

(4) In the cases in the literature one of the lateral ventricles was usually larger than the other. This might have been due to earlier encroachment on one foramen of Monro.

(5) One would suspect a posterior, downward and lateral displacement of the pineal gland in some of the cases.

(6) In the lateral view, the shape of the lesion would be approximately

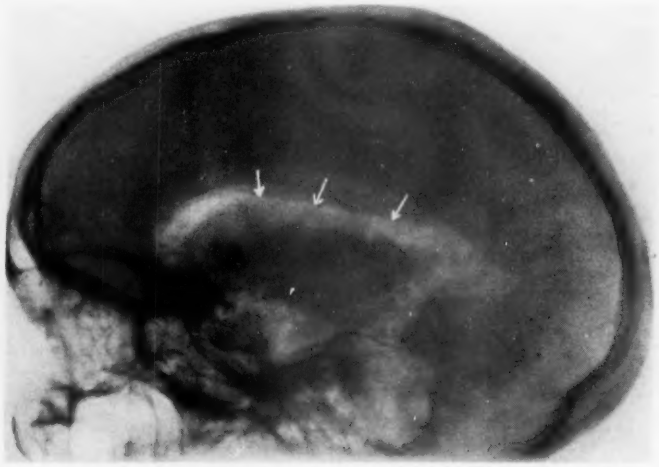

FIG. 25.—Lateral view of same patient as in Fig. 24, showing a flattening of the right ventricle. This is a superficial lesion as indicated by the flattening of the ventricular system. Note the absence of cortical pathways.

the same as that described under the communicating type, the only difference being the increased size of the former and the non-communicating lesion would be dense rather than radiolucent.

General Considerations.—This lesion may cause increased intracranial pressure because of its encroachment on the aqueduct or the foramina of Monro. There are so many lesions that simulate a non-communicating type of cavum septi pellucidi and cavum vergæ that it has seemed important to include a brief description of some of the more confusing ones. From our experience we would strongly recommend a careful study of röntgenograms made in all of the conventional positions before attempting to make the diagnosis.

There is another feature which we have noticed in our patients with septal dilatations, and that is the frequency of the difference in the level of the floors of the bodies of the ventricles. In studying the illustrations of Dandy

and VanWagenen and Aird, their drawings demonstrate the same thing. We have observed this finding in patients in whom the communicating type of cavum septi pellucidi and cavum vergæ has not been demonstrated, and have assumed that it was just an anomaly of the lateral ventricles. In studying this subject, however, we would like to raise the question as to whether this may be a sign of a non-communicating type of cavum septi pellucidi and cavum vergæ (Figs. 12, 13 and 20).

Differential Röntgen Diagnosis.—(1) *Tumors of the Lateral Ventricles.*—Tumors arising from the median wall of the lateral ventricle may closely simulate a non-communicating type of cavum septi pellucidi and cavum vergæ in the postero-anterior projection. Both conditions tend to separate the lateral ventricles and encroach upon the lumen of the ventricular system. Both tend to encroach on the third ventricle. Both may cause dilatation of the ventricu-

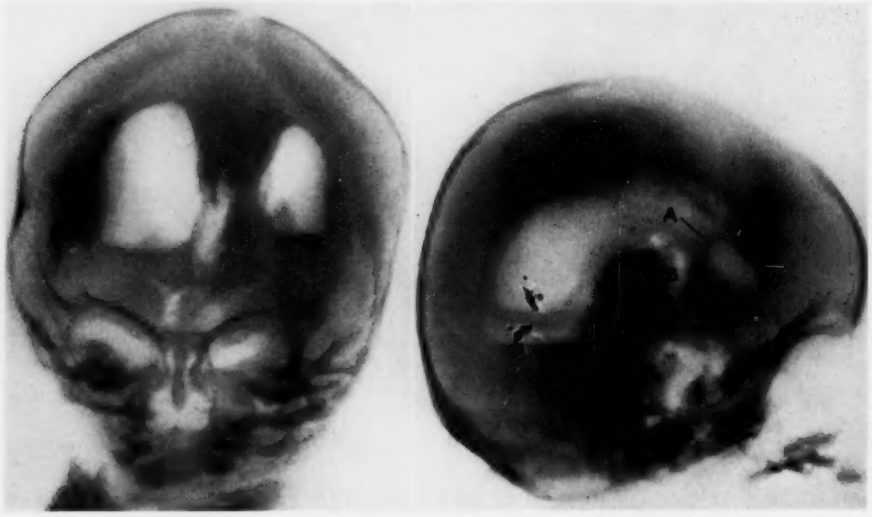

FIG. 26. FIG. 27.

FIG. 26.—Mid-line frontal lobe tumor separating the lateral ventricles. Except for the lack of depression of the third ventricle one might think this was a congenital cyst of the septum pellucidum.
FIG. 27.—Lateral view of same patient as in Fig. 26. Note the encroachment on the anterior horns at A and the backward displacement of the third ventricle at B. Film defect in occipital region.

lar system. In fact, in the anteroposterior view they may be identical in appearance (Fig. 21).

The lateral view may tell the story, however, unless the tumor is large enough to involve most of the medial wall. The tumor may be nodular and occupy only a portion of the ventricle (Fig. 22).

(2) *Solid Tumors of the Septum Pellucidum.*—Appearances similar to those described above.

(3) *Metastatic Tumors.*—Occasionally these tumors occur on the medial wall of the lateral ventricle and if they grow to be of sufficient size, may be confusing. What has been said for tumors of the lateral ventricle will apply to metastatic tumors (Fig. 23).

FIG. 28.—Suprasellar cyst. In the anteroposterior view the periphery of the cyst is outlined by the arrows. Note the absence of subarachnoid markings. Biopsy report was adenomatous cyst.

FIG. 29.—Same patient as in Fig. 28. Encephalogram. Previous transfrontal approach to tumor site. There is a large tumor which elevates the lateral ventricles and almost obliterates the third ventricle at A. At B the calcified periphery of the cyst is seen.

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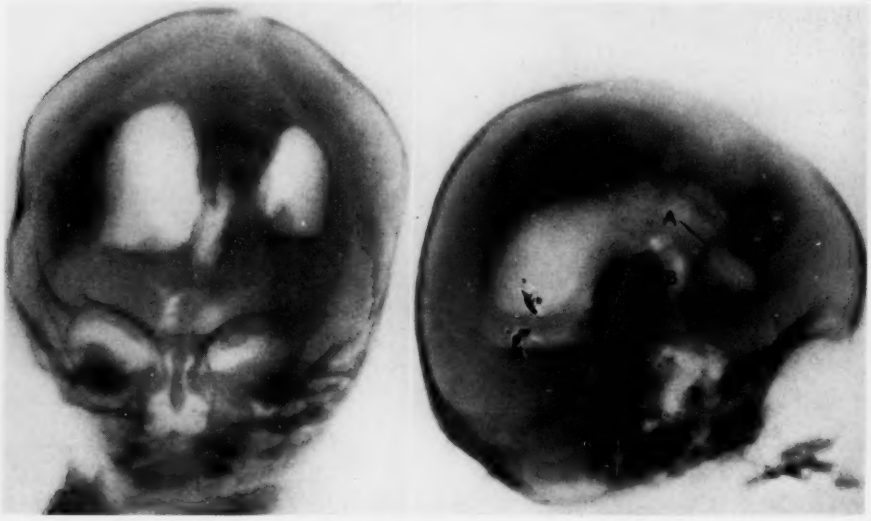

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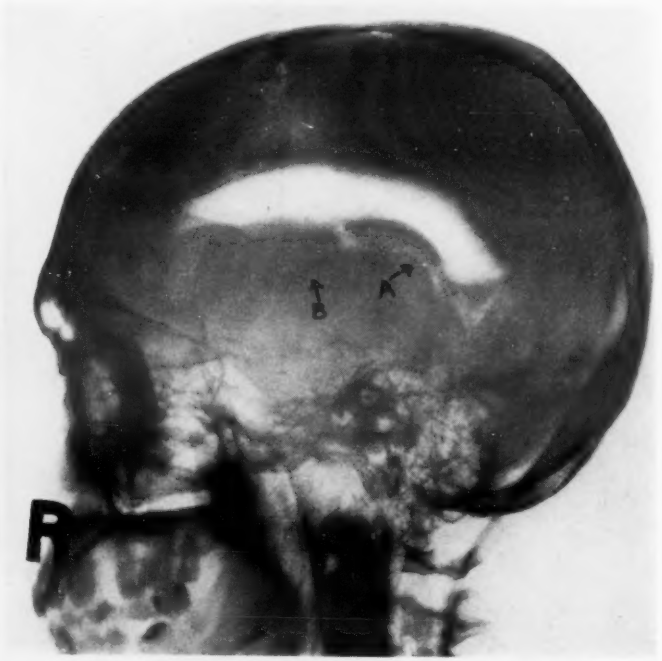

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FIG. 30.

FIG. 31.

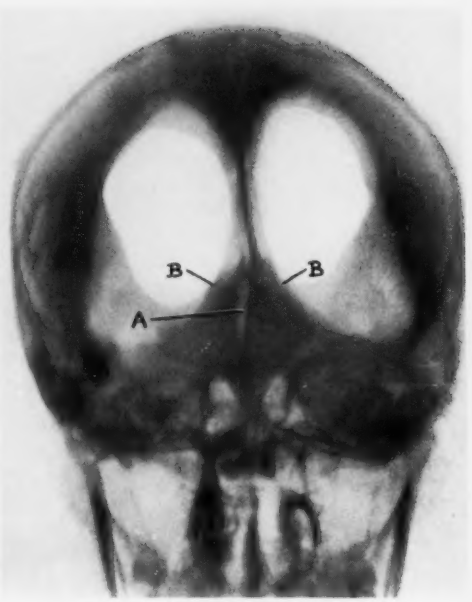

FIG. 32.

FIG. 30.—The third ventricle is encroached upon and displaced slightly obliquely to the right. Note how the posterior and inferior horns of the left lateral ventricle are encroached upon probably due to the growth at A. Diagnosis: mass lesion in the region of the thalamus encroaching upon the lumen of the third ventricle at B and posterior and inferior horns of the left lateral ventricle. Operation: what was thought to be a third ventricle tumor was found. Post-mortem examination showed a large lesion involving the thalamus and invading the third and lateral ventricle on the left side and also extending to the base.

FIG. 31.—Lateral view of the same patient as in Fig. 30. Astrocytoma involving the posterior portion of the optic thalamus, extending into the adjacent internal capsule, third ventricle and posterior horn of the left lateral ventricle. Male, aged sixteen, with headache, vomiting, attacks of momentary blindness and double vision of four months' duration. Choked disk, nystagmus, some instability of gait and station, possible deviation of tongue and palate. Ventriculogram: lateral view shows symmetrical dilatation of the lateral ventricles, dilatation of the foramen of Monro at A, dilatation of the anterior portion of the third ventricle at B. The posterior portion of the third ventricle is encroached upon, C. The aqueduct is not visible.

FIG. 32.—Third ventricle tumor. Male, aged fifteen, with difficulty in walking occurring gradually during past eight months, weakness of back and legs, failure of memory. Routine Röntgen examination showed increased intracranial pressure but a tumor could not be localized. Ventriculogram: postero-anterior view shows a dilatation of both lateral ventricles with no mid-line shift. The third ventricle is very small and is seen at A. Its outline is somewhat irregular. It assumes a perpendicular position. The lateral ventricles are slightly separated at B.

(4) *Corpus Callosum Lesions.*—We have had no opportunity to study any of these cases by cerebral pneumography, but from the sections shown by Alpers and Grant,[1] one might expect that the Röntgen findings in a non-communicating cavum septi pellucidi may be closely simulated by those of a moderate-sized corpus callosum lesion. The encroachment of the callosal lesions upon the roof of one or both of the lateral ventricles may be a differential point.

(5) *Parasagittal Lesions.*—These lesions as described by Masson[9] can usually be differentiated from the non-communicating type of cavum septi pellucidi and cavum vergæ. Parasagittal tumors tend to encroach upon the roof of one ventricle and displace the mid-line structures to one side, including the pineal body (Figs. 24 and 25).

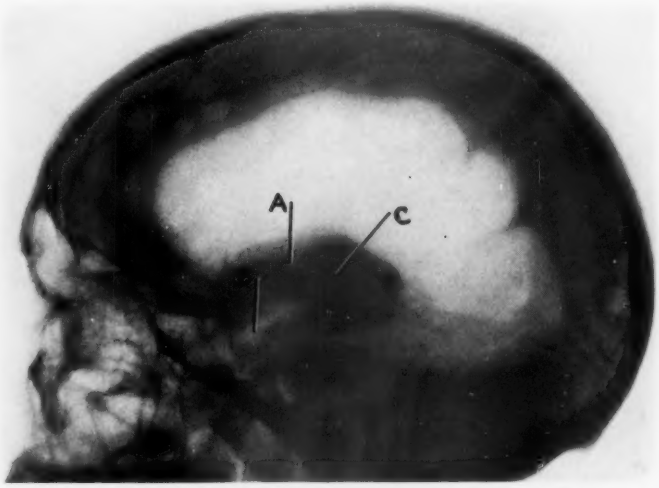

FIG. 33.—Lateral view of same patient as in Fig. 32. The lateral view shows a huge dilatation of the lateral ventricle with considerable waviness in its outline. The foramen of Monro is dilated at A. The third ventricle is almost completely encroached upon. There is considerable space between the foramen of Monro and third ventricle, B; aqueduct of Sylvius which is probably filled in by the tumor at C.

(6) *Mid-line Tumors in the Frontal Region.*—These lesions tend to separate the anterior horns, which on the röntgenogram is evidenced by a widening of the space between the anterior horns. In the postero-anterior and antero-posterior views the appearance may be identical with a dilated septal cavity (Fig. 26).

In the lateral view the anterior horns are definitely encroached upon anteriorly and the third ventricle may be displaced posteriorly. This view gives the real differential diagnostic appearance (Fig. 27).

(7) *Suprasellar Lesions.*—These lesions may get large enough to separate the lateral ventricle slightly from below, but they tend to elevate and encroach upon the third ventricle. The lateral view should clearly differentiate the lesion from any other (Figs. 28 and 29).

(8) *Thalamic Lesions.*—These lesions tend to separate the lateral ven-

lateral ventricles are slightly separated at B.

tricles from below and displace the third ventricle to one side (Figs. 30 and 31).

(9) *Third Ventricle Lesions.*—Occasionally a third ventricle tumor will reach a tremendous size, sufficient to increase the separation of the lateral ventricles. The real site of the lesion can be demonstrated in the lateral view as the encroachment is from below (Figs. 32 and 33).

(10) *Pinealomas.*—These lesions tend to separate the lateral ventricles and encroach on the posterior aspect of the third ventricle. Their posterior and dependent position should prevent one from mistaking it for a lesion of the septum pellucidum (Fig. 34).

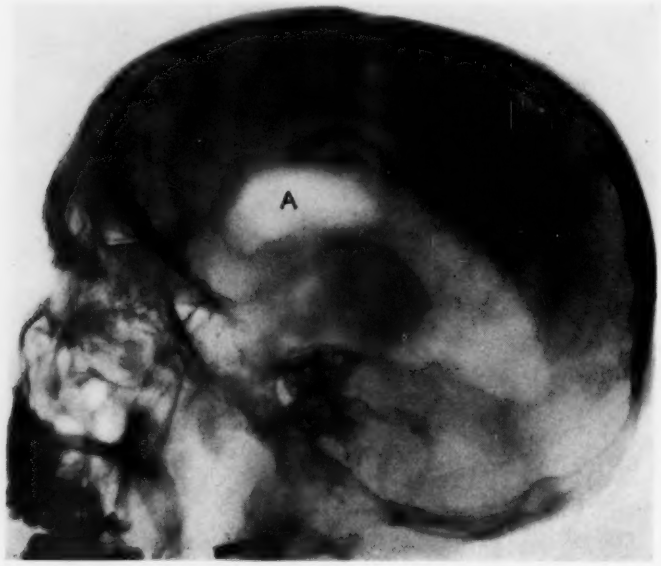

FIG. 34.—Ventriculogram: examination shows a moderate dilatation of the lateral ventricles. The foramen of Monro is slightly dilated. The third ventricle is barely visible, the entire region of the ventricle being encroached upon by the pinealoma. There is no visualization of the aqueduct of Sylvius. Diagnosis: pineal tumor. Occipital craniectomy was done with removal of the tumor which was a pinealoma. Note the translucent shadow at A. This is air in the opposite lateral ventricle. Its shape simulates that of a dilated cavum septi pellucidi.

(11) *Meningiomas of the Olfactory Groove.*—Sometimes a meningioma of the olfactory groove will separate the anterior horns of the lateral ventricles sufficiently to be confusing, but the appearance of the olfactory groove and the bones of the skull should render the differential diagnosis easy.

SUMMARY

The subject is reviewed from the standpoint of the history and anatomical considerations. Four new cases are reported, and the Röntgen diagnosis is considered in detail.

We wish to express our appreciation to Dr. Charles H. Frazier and Dr. Samuel B. Hadden for the privilege of reporting their cases. All the patients used in this article were with one exception from the neurosurgical division of the Hospital of the University of Pennsylvania.

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TRANSIENT HYPOTENSION AS A FACTOR IN CEREBRAL THROMBOSIS

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It is well known that a fall in systemic blood-pressure may induce a variety of phenomena arising from disturbance of the cerebral circulation. The list of such symptoms includes, on the one hand, momentary dizziness, syncope, transient aphasia or paralysis, and on the other, more or less permanent states of hemiplegia. In each the final cause is the same, a local ischæmia causing anoxæmic injury to the brain with more or less softening and permanent damage according to the nature and duration of the interruption of blood flow. However, the steps by which the lowering of systemic blood-pressure acts may vary widely; in one, there is nothing more than momentary local anæmia; in another, arterial spasm plays a part; and in a third, arterial occlusion by thrombosis is precipitated by this fall in pressure. This last, although of frequent occurrence and of great practical importance, has not received the attention it deserves.

Cerebral thrombosis is a frequent cause of cerebral damage; its diagnosis is of importance both for prognosis and treatment. In all aspects of the subject it is essential that the part played by transient hypotension should be emphasized.

Factors in Transient Cerebral Attacks.—Local anæmia is a common cause of mild transitory symptoms. Any sharp fall in blood-pressure or disturbance of circulation such as occurs in some individuals upon assuming the upright posture, is sufficient to excite symptoms of cerebral origin.

Spasm of the cerebral arteries has for many years been held to be a frequent cause of transient cerebral phenomena such as aphasia and paralysis. This view was maintained by many clinicians (Osler[1]), in spite of the evidence accepted at that time that the cerebral vessels had no vasomotor nerves, and also in spite of the fact that such transient symptoms were most common in individuals with arteriosclerotic arteries, which it would seem could not be expected to undergo spasm, inasmuch as their muscular coat is greatly impaired and their walls fixed and rigid.

Today, however, as a result of the investigations of Penfield[2] and others, it is accepted that both the deep and superficial cerebral vessels possess both constrictor and dilator nerves. Stimulation of the cervical sympathetics causes constriction; stimulation of the vagus induces vasodilatation.

Demonstration of a vasomotor control of the cerebral vessels confirms clinical studies of patients with cerebral vascular attacks, and agrees with observations made on the arteries of the exposed brain and of the retina. Until vasomotor control of the cerebral vessels was proved, all changes in

cerebral blood flow had to be explained as secondary to alterations in the state of the systemic circulation. The proof of vasomotor control opened the way for a far more complete study and better understanding of the physiology and pharmacology of the cerebral circulation. Cobb[3] has given an excellent summary of the advances in the field, many of which have appeared during the past five years from the Department of Neuropathology of the Harvard Medical School.

French investigators have for years been particularly interested in this subject, influenced no doubt by the views of Foix and Leriche. The French literature is extensively summarized in a recent monograph by de Seze.[4]

Cobb admits that the presence of a vasomotor system does not prove that this mechanism is functionally important under normal conditions. Probably the state of the cerebral circulation at any given moment is the result of a combination of influences arising from vasomotor control and from systemic blood-pressure. Possibly the two act in opposite directions in the effort to maintain a constant and adequate blood supply to the brain. Thus histamine, acetylcholine and other agents will cause dilatation of the cerebral arteries with an increase in blood flow even though the systemic blood-pressure is falling.

Even greater uncertainty exists concerning the part played by the vasomotor system in cerebral vascular attacks of more than momentary duration. Fleming and Naffziger[5] stress the importance of a fall in systemic pressure; Riser, Meriel and Planques[6] believe that spasm is not the only factor at work.

Uncertainty exists as to the nature of the mechanism by which certain conditions lead to cerebral vascular phenomena. The hemiplegias which follow upon severe loss of blood offer a good example of this. Worms[7] has collected instances of hemiplegia following therapeutic bleeding, epistaxis, hæmatemesis and uterine bleeding. Worms claims that the pressure may remain unchanged in certain instances of this kind. The reported instances in which a cerebral vascular accident followed a therapeutic bleeding have with great consistency been in elderly individuals with arteriosclerosis and hypertension. Usually the pressure has been lowered by the bleeding as, for example, in the two cases reported by Vincent and Darquier[8] in which the removal of 800 cubic centimetres of blood was followed by a distinct drop in systolic pressure and by hemiplegia. The type of individual is that suitable for thrombosis but also, of course, for cerebral hæmorrhage so that this question remains undecided. The subsequent course of some of the cases somewhat supports the thought of thrombosis.

Actual thrombosis of a small cerebral vessel may cause only transitory symptoms and it is very probable that some such transitory attacks usually attributed to ischæmia or spasm are due to thrombosis.

Factors Favoring Cerebral Thrombosis.—To quote Aschoff,[9] "there is no doubt at all, to use a mathematical figure of speech, that thrombosis is the function of a number of variables. There is not a single cause, but quite

a number of different conditions which are closely related to the occurrence of thrombosis."

1. *Change in the Vessel Wall.*—Except as a result of embolism, arterial thrombosis will probably not occur in the absence of disease of the artery wall. Thrombosis may follow the acute arteritis of certain acute infections, or the subacute endarteritis of syphilis. It is more common, however, in the elderly group with chronic arteriosclerosis. The narrowing and tortuosity of the lumen, and the roughening of the intima offer favorable conditions for the origin of a thrombus and for the eventual occlusion of the vessel.

2. *Changes in the Blood.*—Certain distinct diseases of the hæmolytopoietic system such as leukemia, polycythæmia and thrombocytosis result in such markedly altered blood as strongly to favor, and often cause, thrombosis. These cases belong, however, in a special category. More often the blood change favoring thrombosis consists in an increased viscosity such as may occur from the dehydration of severe burns, cholera, intestinal obstruction, *etc.* The presence of this dehydration is often best recognized by the greatly increased number of erythrocytes per cubic millimetre. Practically it may be difficult to evaluate the influence of increased blood viscosity for a lowered blood-pressure may also be present.

3. *Changes in Blood Flow.*—Any slowing of blood flow favors thrombosis. In the cerebral circulation this slowing can be brought about by a fall of systemic blood-pressure unless locally compensated for by vasomotor control. Or spasm itself if of sufficient duration may permit the formation of a thrombus if the artery is appropriately diseased. Clinical experience suggests that the influence of systemic blood-pressure on the cerebral circulation is often greater than can be neutralized by the cerebral vasomotor control. This, as might be expected, is particularly true when the artery is sclerotic and when sudden change occurs in the systemic blood-pressure. Paroxysmal rise of blood-pressure often precedes rupture of a cerebral vessel;[10] transient drop of pressure is probably of equal importance in the final steps of thrombotic occlusion.

Hypotension and Cerebral Thrombosis.—Cerebral thrombosis if embolism, trauma, and acute infection are excluded, occurs far more commonly in two types of patient: the middle-aged syphilitic with syphilitic endarteritis and the elderly arteriosclerotic with hypertension. In both, the incident immediately preceding the vascular accident is such as to suggest that a sharp fall in systemic blood-pressure has been present.

Before discussing the incidents which frequently precede cerebral thrombosis and which it seems act to induce the thrombosis by lowering the general blood-pressure, it is important that the great variability of blood-pressure be remembered. Further that this variability is greater in hypertensive individuals than in normal ones.

In the normal individual it is known that the blood-pressure varies considerably during the day; it is higher late in the afternoon (Erlanger and Hooker[11]) and also after meals. (Weysse and Lutz.[12] Howell[13] observed

years ago that the pressure may fall during sleep; Mueller[14] found that the maximum drop occurs about two hours after falling asleep and averages about 24 millimetres. MacWilliam,[15] however, quite properly points out that we must differentiate between quiet and disturbed sleep; during the latter the systolic pressure may rise from normal to over 200 millimetres. In hypertensive patients these variations are exceeded and it is easy to picture that, even without invoking more active influences, these variations may readily be of importance in the production of various types of cerebral vascular accidents.

Factors which in moderation may bring about a rise in blood-pressure will in excess produce the opposite result. This fact has caused confusion in several statistical analyses. Thus, for example, exertion if severe and temporary will cause an immediate increase but when continued to fatigue will result in a more prolonged depression. Acute emotion will increase, but continued stress lower, the pressure. Normal meals are followed by an increase; gross gorging often by sharp lowering of pressure. It seems clear that such influences act just as many drugs do, in opposite directions according to the dose.

Infection, even if not severe or prolonged, often lowers the pressure in either the normal or the hypertensive individual. Influenza, tonsillitis, *etc.*, may be sufficient precursors of thrombosis in a suitable subject. Not only is the pressure lowered but some degree of dehydration occurs incident to the fever and restriction of fluid intake. Acute gastroenteritis may also favor thrombosis by lowering the pressure and causing dehydration by fever, vomiting and diarrhœa. In the sclerotic hypertensive individual acute indigestion may be a serious threat.

Surgical operations, especially in the elderly, are apt to be followed by periods of lowered pressure. This is true even in the absence of anything which could remotely be termed "shock." In true shock, the pressure, of course, falls far below its habitual level whether this has been normal or elevated. The lowered pressure manifests itself in many ways as, for example, anuria, and the conditions in the sclerosed cerebral vessels must at such times be extremely favorable for thrombosis.

In the sclerotic hypertensive, the blood-pressure may gradually fall if the patient is bed-ridden, and in such individuals therapeutic measures directed at lowering a pressure which may be far above normal but which is habitual for that individual may have harmful results. Elderly arteriosclerotics with progressive asthenia often develop cerebral softening due to multiple points of thrombosis.

An analytical review of the literature and of the records of cases of cerebral vascular attacks in the files of the Medical Division of the Hospital of the University of Pennsylvania confirms the belief that cerebral thrombosis is a frequent cause of such cerebral accidents, that it does occur in the elderly patient with arteriosclerosis and hypertension and that the attack is often

immediately preceded by some incident of the type which tends to sharply lower the blood-pressure.

In the literature the frequency of cerebral thrombosis has not been sufficiently emphasized nor the fact that a thrombosis may simulate severe cerebral hæmorrhage, on the one hand, or the most trifling spasmodic ischæmia, on the other. But the importance of preceding hypotension has received even scantier attention.

Unfortunately, the earlier literature too often fails to supply post-mortem proof of the nature of the lesion causing cerebral vascular attacks. This applies, for example, to the cerebral attacks occurring in patients with "weakness of the heart." (Edes.[16]) It was realized that embolism occurs in certain cardiac diseases but the majority of cases are attributed to thrombosis from slowed circulation.

Even in recent case records the incidents preceding the attack of cerebral thrombosis are often inadequately detailed; the importance of this point has not been appreciated. Also records of the blood-pressure immediately prior to the attack are rarely obtained. Usually the patient is known to have been hypertensive, and after the onset of the attack the pressure is found to be below its habitual level. This does not help for it may be the fall in pressure which follows a cerebral hæmorrhage rather than the continuation of a temporary hypotension, which has predisposed to thrombosis. Both cerebral hæmorrhage and thrombosis occur in arteriosclerotic individuals with habitual hypertension; in the former the cerebral accident is preceded by a rise in pressure, in the latter by a fall.

It is interesting to compare the conditions favoring cerebral thrombosis with the list of incidents described[17] as preceding coronary artery occlusion. Usually there is some unusual departure from the patient's ordinary habits of living and the list includes such factors as prolonged exertion, loss of sleep, fatigue, overeating, acute infection, surgical operation, *etc.* It would seem reasonable that temporary hypotension may play a part in the pathogenesis of both coronary cerebral artery occlusion and that the two conditions in this respect at least may be analogous. Both in the literature and in our own records, cases with symptoms suggesting simultaneous thrombosis in both areas have occurred.

Unfortunately the recognition of thrombosis of a cerebral artery as the cause of a cerebral vascular accident is far from easy. Both thrombosis and hæmorrhage are apt to occur in the same type of patient and both are apt to involve the middle cerebral artery or one of its branches. The resulting neurological picture is often of no assistance in differentiating the causative process.

In the review of our case records a number of instances were found in which the clinical diagnosis of thrombosis was proved incorrect by the post-mortem examination. In some of these the clinical evidence favoring thrombosis seemed convincing but hæmorrhage was the lesion present. A case in point was that of an elderly motorman who while at work developed a

transient hemiplegia. He did not lose consciousness and walked to the ambulance with assistance. In the hospital he rapidly improved and our diagnosis was thrombosis. Within two weeks while sitting quietly on a chair he had a typical apoplexy with complete hemiplegia on the side opposite to that of his first attack. At autopsy two hæmorrhages were found, one on each side at identical positions. One was older than the other but they were of about the same size and it was difficult to understand why the former gave such a mild attack with transient phenomena, while the latter gave the characteristic picture of a fatal apoplexy. Too often a post-mortem examination of the brain is not made in cases of fatal cerebral accidents. Without the post-mortem examination, the diagnosis cannot be considered as sure. The diagnosis is, however, well worth the making, in that both prognosis and treatment differ according to the lesion. One should, therefore, whenever possible, attempt to analyze the incidents preceding the attack and to make use of the probable shift in blood-pressure as one item in the diagnosis. Venesection, lowering of intracranial pressure, lowering of systemic blood-pressure would all favor further thrombosis. That the pressure is found above the physiological normal is no justification for assuming that it is above the patient's habitual level and unfortunately it is in these very patients with habitual hypertension that blood-pressure lowering procedures, such as the administration of nitrites,[18] have their maximal efficacy. The greater the initial degree of arterial tonus the greater is the drop in systolic pressure produced by nitrites.

Therapy in the opposite direction may be helpful. If thrombosis is suspected, every effort should be made to raise systemic blood-pressure and improve blood flow through the cerebral arteries. The patient should be kept warm and fluids freely administered. Should the true lesion be hæmorrhage these measures will probably do as little harm as the usual therapy of that condition does good. Evidence seems to favor the use of caffeine or alcohol to improve cerebral blood flow.

In prevention of cerebral thrombosis this same line of reasoning applies. Deviations from the patient's usual life should be avoided; fatigue prevented. Prompt attention should be paid to even mild infections. Every effort should be made to maintain the blood-pressure and blood volume during such unavoidable incidents as occur. Emotional stress, fatigue, infection, indigestion, *etc.*, should lead the patient to summon his physician at once.

CONCLUSION

Temporary lowering of blood-pressure is a frequent occurrence in hypertensive arteriosclerotic individuals and is often the factor determining the onset of cerebral thrombosis. Appreciation of this fact is of assistance in the diagnosis of cerebral thrombosis and is of the utmost importance in the treatment of the attack and in the prevention of extension or repetition of the process.

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ENCEPHALITIS LETHARGICA

WITH REPORT OF CASES

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In my lectures to students I have often referred to the fact that most of the diseases known to us were discovered, described and named long ago and that strictly new diseases are comparatively few. I am now, however, speaking of a disease that may be called new, a disease virtually born within our own time. It is true there are in the literature of the eighteenth and nineteenth centuries a few references, of which I shall speak later, to conditions that resemble encephalitis lethargica, particularly the mysterious affection raging in Northern Italy in the early nineties called Nona, but the accounts are not clear. At any rate, the clinical picture of these diseases had passed into oblivion. It can, therefore, be said quite justly that the disease was first recognized during the Great War. The earliest definite description was given by Freiherr Constantine von Economo, a Greek physician living in Vienna, who died recently. Because in his early cases somnolence was a striking feature, he called the disease lethargic encephalitis. Cruchet, a French observer with whom von Economo fought a bitter battle for priority, proposed the name epidemic encephalitis. von Economo in his thorough study of the literature found that there are records of outbreaks of some type of sleeping sickness and that these not rarely followed epidemics of influenza. It is interesting that about 1835 Berndt, in Germany, used the very name lethargic encephalitis, a circumstance that was totally forgotten. The literature of the disease has grown so vast since 1917 that the Matheson Commission of New York in its report in 1929 had collected 428 pages of references.

There was a close relation between the early cases in 1918 and 1919 and the pandemic of influenza. This relation has led many to look upon lethargic encephalitis as a sequel of influenza and caused by it. All that we can definitely say is that influenza may predispose to encephalitis. If both diseases are of virus origin, as is suspected, the relation may be closer than we now know. Indeed, Earl B. McKinley and Elizabeth Verder believe that encephalitis is brain "flu."

I need not waste time discussing the etiology. We know the disease is infectious but the cause still eludes us. As I have said, the present tendency is to consider encephalitis a virus disease and to look upon the nasal passages as the portal of entry whence perhaps by way of the olfactory nerves the virus passes into the brain. A number of investigators are inclined to believe that the virus of herpes may be identical with the encephalitic virus but here too conclusive proof is lacking. Herpes itself is a very rare symptom in encephalitis.

A good deal of evidence exists to prove that the St. Louis epidemic of encephalitis was caused by a filtrable virus. Although analogy is not strong scientific argument, it permits the tentative conclusion that the earlier disease, described by von Economo, was also of virus origin. Rosenow would attribute both to a streptococcus but the majority of workers are not inclined to agree with him.

There is no definite indication of any connection between occupation and liability to infection. Among the adult male patients there were nearly as many occupations as there were cases of illness. In Vienna, however, it seemed that the members of the professions and skilled laborers, especially metal workers, were noticeably attacked. In this country the disease was fairly common among physicians. The white race has been most affected but whether that was due to greater exposure or greater susceptibility is still unsettled. Among my own patients, the female sex predominated; the youngest patient, a man, was twenty-three; the oldest, a woman, was sixty years at the onset of the disease.

Direct contagion is possible. In a Veterans' Hospital a man suffering from encephalitis was lying between two surgical cases. Lighted cigarettes were passed between them and the patients on both sides came down with encephalitis. Contagion was not observed in the St. Louis epidemic.

There are a number of instances of multiple infections. There was an explosive outbreak in a Girls' Home in Derby, England, during August, 1919. Twelve cases with five deaths occurred among the inmates in less than two weeks. In an asylum for young women in Mulheim on the lower Rhine in the summer of 1922 there were twenty-eight cases with thirteen deaths in twenty days.

Mortality.—The mortality varies in different years; it is estimated to be about 40 per cent. in this country. In England and Wales from 1919 to 1927 it was 47.8 per cent. In Paris, Illinois, the mortality was 37 per cent.; in St. Louis 20 per cent.

Pathology.—The disease is an inflammation of the central nervous system, especially of the basal ganglia, the mid-brain—chiefly the oculo motor nuclei and substantia nigra—and the pons and medulla. However, no part of the nervous system is exempt. No disease except syphilis is so promiscuous in its cerebral localization.

The terrible Parkinsonian syndrome of the disease rests upon a chronic progressive degenerative process in the entire nervous system with a predominance of the mesencephalic, diencephalic and striopallidal regions, the principal seat of involvement being the substantia nigra. This fact now generally recognized is an important gain in our knowledge of the disease and affects prognosis and may in time affect treatment.

Symptomatology.—The symptoms as a rule point to some acute infection of the central nervous system. There is fever, occasionally hyperpyrexia and at times headache. Of great diagnostic importance are ocular disturbances—blurring of vision, diplopia, ptosis and other paralyses, alteration in the

pupillary light reaction, inequality of the pupils, and nystagmus. Papill-œdema, similar to that found in brain tumor, may occur. In typical cases there is somnolence so that the patient may go to sleep while talking, even before completing a sentence. He can usually be roused but soon falls off into a deep sleep which may proceed to the stage of coma. In some cases the opposite phenomena are found—insomnia and great restlessness. Stiffness of the neck and Kernig's sign may be present; facial and other paralyses have been noted. The respiration is often disturbed—very rapid, irregular or of the Cheyne-Stokes type.

There is not much change in the tendon reflexes but the abdominal reflex is frequently absent. The muscles may be the seat of spasmodic or myoclonic contractions; hiccough is often present. Incontinence of urine and fæces or retention of urine may occur. Hyperidrosis is common.

Skin eruptions are frequent—a fine macular rash on the chest, neck and face or pigmentation in local areas or papular eruptions resembling acne or fine vesicles of herpetic type.

The cerebrospinal fluid usually shows a slight increase in lymphocytes, from 10 to 50 per cubic millimetre, an increase in globulin and in sugar, and an increase in pressure. Sometimes a luetic gold curve is obtained.

Course.—The course of lethargic encephalitis presents great variability. Some cases are hyperacute with death in two or three days; the majority, however, run a chronic course and for that reason the prognosis as to permanent recovery is very poor since from 60 to 70 per cent show residual signs and symptoms. There is thus abundant evidence that lethargic encephalitis is a chronic disease, its later manifestations, as I have already said, being due to progressive action of the virus on the nervous system.

The Parkinsonian Syndrome.—While this tragic sequel may set in early, it is usually a late event. In one of my cases the interval was twelve years; in a case reported by J. M. Perkins[1] it was nineteen years. The outstanding features are a muscular rigidity with flexion of the trunk, an immobile mask-like face, a slow shuffling gait with propulsion and festination, and a decreased arm swing on walking. In these several respects it closely resembles the old fashioned paralysis agitans but tremor is less common. The two conditions, post-encephalitic parkinsonism and paralysis agitans parallel each other so closely that some writers have concluded that the latter disease is also the result of an antecedent but overlooked acute attack of encephalitis. My opinion leans toward the view that post-encephalitic parkinsonism and paralysis agitans are etiologically two distinct diseases although closely allied in local habitation and in symptomatology.

In addition to the characteristic statuesque rigidity, we have a variety of other symptoms—impairment of associated movements, blepharospasm, ocular spasms, and other myoclonic movements or ticks. There is drooling of saliva, oiliness of the skin; hot flashes and objective sensation of heat of the skin, and painful local spasms, usually in the feet or legs. The eye symptoms in

chronic cases are of particular interest. The pupils are often unequal and the reflexes impaired; ptosis and weakness of conjugate movements occur; very annoying are spasms of ocular movements, especially in the upward direction. Patients have expressed this by saying that the eyes get caught so that they are unable to look down. Tremor so characteristic of ordinary paralysis agitans is not common in post-encephalitic parkinsonism. The majority of patients complain bitterly of a sense of great fatigue. Somnolence and lethargy almost as great as in the acute stage may be present.

Mental changes are among the most tragic of the sequels of encephalitis. They range from mild types of neurosis, psychasthenia and irritability to mania, confusion and paranoid and schizophrenoid syndromes. A variant of the mental effects is an alteration in character often seen in children with chronic encephalitis. Such children exhibit failure of memory, mild or grave disorders of conduct, and general mental deterioration. One of my patients, a dignified adult, developed the habit of talking out loud to himself in public places.

A number of other nervous disturbances may occur in the course of encephalitis—epileptiform convulsions, hyperthermia, amyotrophic forms of spinal sclerosis and various types of myoclonic spasm. In some cases the most striking symptom is an extreme fatiguability. Hiccough is also a fairly common symptom.

Metabolic disorders have been observed: obesity and emaciation, which may be associated with atrophy of the ovaries and testicles. Diabetes insipidus and diabetes mellitus have also been reported as sequels to an illness that had some of the characteristics of lethargic encephalitis.

Impotence may appear early, soon after apparent recovery from the acute phase, more often, however, it is a late symptom. One of my patients, a tall, vigorous man of twenty-eight years, had lethargic encephalitis in 1920. He came to me in September 1932, complaining of drowsiness and loss of potency. I may say incidentally that he is much improved under treatment consisting of caffeine by mouth and strychnine hypodermically.

The chronic stage is a mysterious affair—it bears little or no resemblance to the acute phase and may come on years after the primary attack, the patient having been fairly normal in the interval. Is the chronic stage a reinfection or a lighting up of the smoldering remains of the acute infection? We cannot answer these questions definitively. There is a certain analogy to syphilis which is often latent for many years and then breaks forth as tabes dorsalis, paralytic dementia or cardiovascular disease—none of which bears any resemblance to the chancre or to the secondary lesions of lues.

The recent epidemics, since the original outbreaks during the War, show certain clinical differences that may indicate a difference in etiology. All appear to be due to a filtrable virus—this applies to von Economo's type, in which a neurotropic herpes virus is suspected, to the Australian X disease, to encephalitis japonica (encephalitis type B of which eleven outbreaks have

been noted), and to the well-studied St. Louis epidemic. In the last-named the investigations of Muckenfuss, Armstrong and Webster,[2] Muckenfuss, Armstrong and McCordock[3] and their associates have shown that the virus can produce disease in monkeys and white mice and that it is neutralized by the serum of individuals who are convalescing from encephalitis. This is strong evidence that the virus was the etiological agent in the St. Louis epidemic.

Sporadic cases of encephalitis have occurred after smallpox vaccination, after measles, chickenpox and other acute infectious diseases. Josephine B. Neal[4] the best authority in this field, admits that the cause of these types is as yet entirely unknown. The lesions of hydrophobia are such that this disease is properly called an encephalitis.

The encephalitis virus has a selective affinity for the basal areas of the brain, that is, the striothalamic region and the brain stem proper including the pons and the medulla. No part, however, as already mentioned, of the central nervous system is exempt.

The St. Louis epidemic was characterized by the presence of meningeal symptoms. Some cases began acutely and had a short duration with high fever. Others began more insidiously. A third group was very mild and presumptively only belong to the epidemic disease. There were very few sequelæ in the St. Louis epidemic but not enough time has elapsed to say that none will occur. Somnolence and stupor usually persisted until defervescence; eye symptoms so common in the earlier outbreaks were practically not observed. The spinal fluid showed an increase in cells, of from 100 to 200, usually mostly lymphocytes, an increase in pressure, in globulin and in sugar. The average white cell count was from 10,000 to 14,000 but in a number there was leukopenia causing, in the early cases, the suspicion of typhoid fever to arise (D. P. Barr[5]). Among 400 cases tabulated by Doctor Muckenfuss there were sixty-eight deaths (20 per cent.), most of them due to complications, and chiefly in the older age groups.

The incubation period was difficult to determine but as near as could be told it was between four and twenty-one days. There was no definite evidence of contagion, multiple cases being rare. When they occurred they could be attributed to independent and more or less simultaneous infection. There is no evidence that the disease was water- or insect-borne; at any rate mosquitoes that had bitten encephalitis cases did not when they bit other persons transmit the disease. That fact by itself does not rule out an insect vector inasmuch as Merrill, Lacaillade, Jr., and Ten Broeck[6] have shown that two strains of salt marsh mosquitoes are capable of transmitting equine encephalomyelitis.

It is interesting that before the St. Louis epidemic, Paris, a small town in Illinois, had had an outbreak of thirty-eight cases of a similar disease with a mortality of 37 per cent. Outbreaks resembling that in St. Louis occurred in Kansas City and other western communities.

The Economo type is usually a disease of the winter months but it has occurred at other times. The St. Louis type was a disease of the summer months. This fact, the clinical differences, the absence of ocular palsies and of psychomotor sequelæ have led to the conclusion that the von Economo and the St. Louis types are distinct diseases, a view that is, however, not shared by Josephine Neal.

Diagnosis.—It is evident from the great variability of the symptoms that one must carry a multiplicity of clinical pictures in mind if errors in diagnosis are to be avoided. The acute forms simulate many other diseases—tuberculous meningitis, syphilis of the central nervous system, brain tumor, botulism.

The diagnosis of brain tumor is at times one of the most difficult problems presented to the physician. Diplopia, somnolence, hiccough may be produced by a cerebral neoplasm, and these symptoms, so suggestive of lethargic encephalitis, may be associated with choked disk in cases of the latter disease. The history of an antecedent attack of influenza or of an undetermined febrile seizure together with a great variability of the symptoms and with the changes of the spinal fluid mentioned above points to lethargic encephalitis. In tumor of the brain the family history is of some importance. Not infrequently there is a record of tumor in some other member, not necessarily a close relative. Usually the course of encephalitis with brain-tumor symptoms is more rapid than that of true tumor.

Post-vaccinational encephalitis is rare. It develops in children from the first to second year and comes on usually in from ten to thirteen days after vaccination. Anything developing after seventeen days is likely to be tetanus.

Other conditions with which lethargic encephalitis may be confused are uræmia, diabetic coma and various psychoses. It is not necessary to discuss the differential diagnosis in detail—if the types are borne in mind, the methods of differentiation will occur to the observant physician.

Botulism, a form of food poisoning, may simulate encephalitis very closely in the beginning but is usually a condition affecting a number of persons at a time, and a history of the common ingestion of some particular food is readily obtainable. Botulism as a rule is more acute, the patient either dying or recovering in a short time. Where the thought is borne in mind, tests for the botulism organism *Bacillus botulinus* or its virulent toxin may be made.

The distinction between encephalitic parkinsonism and true paralysis agitans is difficult. As a rule, the latter occurs later in life and is more slowly progressive; conspicuous mental changes usually are absent, tremor is more pronounced and there is absence of the history of an acute attack. However, since encephalitic parkinsonism may ensue many years after an acute seizure, it is always possible that the history of the acute attack is forgotten—hence that particular feature, if absent, does not justify by itself a diagnosis of paralysis agitans.

Treatment.—The number of drugs and other forms of treatment recom-

mended is large but not a single one has proved to be a cure. The Matheson Commission[7] came to the conclusion that hyoscine and analogous drugs have some value in controlling tremor and rigidity but they have no specific effect on the encephalitic process. In my first acute case I used Rosenow's serum. A terrific urticaria with painful joint swellings followed. While the patient recovered from one of the worst attacks of encephalitis I have seen, it would not be fair to ascribe his recovery to the serum. *Post hoc* is not necessarily *propter hoc*. All conscientious writers agree that there is no specific agent, and that nothing is now known that can arrest the progress of the disease if it has a mind to progress. Spontaneous remissions occur which might be attributed by an uncritical observer to the drug last used.

Among non-specific measures that may prove comparatively useful are lumbar puncture when the pressure is high, sedatives in the stage of excitement—chloral hydrate, luminal—and to promote cerebral decompression, concentrated solutions of glucose intravenously. Active immunization with the infecting virus seems feasible when once the virus is obtained in usable form. Immune rabbit's serum has also been employed. With these agents Doctor Neal has secured benefit both in the acute and in the chronic phases.

In the parkinsonian form benefit is realized from hyoscine and allied drugs, stramonium, scopolamine, *etc*. Hyoscine hydrobromide has given me the best results. I begin with doses of 1/200 grain, two or three times a day. Usually the dose has to be increased. One of my patients took 1/50 grain four times a day. It undoubtedly quiets the tremor and lessens the tension in the muscles. Its disagreeable bi-effects are dryness and at times indigestion.

Menard and Hurxthal[8] laud the use of stramonium. No noteworthy results are obtained with less than five to seven grains of powdered leaves. Muscle rigidity is relieved, mental retardation and pillroll type of tremor lessened, excessive salivation invariably relieved. Patricia Steen[9] believes that convalescent serum might be dangerous; she doubts the value of Rosenow's serum, but thinks that Levaditi's brain emulsion might be of value. In her opinion stramonium is the drug of choice.

Fever therapy in the form of diathermy or malarial or bacterial injections seems to produce no permanent benefit. It may even do harm. Hot baths are useful—they relax the muscle tension.

Muscular exercises having as their objective the training of the stiffened muscles and the correction of the disordered equilibrium are very helpful. Ordinary massage has not proved of value in my experience.

Serious conduct disorders in children are most satisfactorily dealt with in special clinics such as those known as Child Guidance Clinics. Perhaps the problems presented by the milder types of these disorders may be best solved by the newer psychiatric methods among which psycho-analysis occupies a leading place.

CASE REPORTS

CASE I.—S. P., a youth of twenty-three years, was suddenly seized in July, 1924, with diplopia, weakness, fatigability and shooting pains in the head and along the course of the first division of the fifth nerve. This last persisted only for one night. He was not obliged to go to bed. Five weeks later he had difficulty in urination and had to be catheterized three times a day. This trouble cleared up after a time. Three months later he began to show distinct mental retardation and physical weakness. Having previously been a good gymnast he was now scarcely able to do anything because of muscular weakness. He had some frontal headache, occasionally vertigo, internal squint, insomnia and increased irritability. When last seen in October of 1933, he had all the neurological findings of paralysis agitans and was practically helpless. There is one interesting fact in the history. Thirteen months before the onset of his diplopia he had had a very brief illness characterized by dizziness, headache and nervousness. Although it lasted but a short time and scarcely made any impression upon him, it may have been the starting point of his trouble.

CASE II.—Dr. L. J., twenty-six years old at the onset of his trouble, had an attack of "influenza" in 1923 which was followed by insomnia and myoclonic twitching and involuntary utterances lasting thirteen days. Thereafter he was very sleepy. He returned to work in two months but continued to have an overwhelming desire to sleep as well as easy fatigability and lack of energy. In 1926, about two and one-half years after the original attack, he showed lack of coördination in the arms and legs, disturbed balance, stiffness in left arm and shoulder and a masklike face with drooling of saliva. None of these symptoms was observed primarily by him but by his mother. His memory also began to fail. I saw him at that time. He had typical parkinsonian gait and carriage and physiognomy, with salivation, a slow monotonous speech and lack of initiative, but there was no tremor at any time. This lack of initiative came into prominence under rather odd circumstances. Through the kindness of the H. K. Mulford Company I had received some encephalitis serum prepared from an organism isolated by Miss Evans of the Hygienic Laboratory in Washington. I had ordered the serum to be given and happened to come to the hospital at the very moment when my assistants were preparing to inject it. I asked the patient whether he had ever had any serum previously. He pondered for a little while and then said, "Oh yes, many years ago I had tetanus antitoxin." I requested an intradermal test. Almost immediately the man's whole arm swelled up and he became quite ill. Thereafter, no matter how small the dose we tried, as long as there was a trace of the serum in the injected material, there was a local reaction in the form of a wheal. Finding it impossible to desensitize the man we gave up all idea of using the serum. This was so interesting that I asked him to go to the College of Physicians and look up the subject of anaphylaxis as it related to our experience with him. It was a long time and only after repeated urging before I succeeded in having him give me a few abstracts and yet he had declared himself profoundly interested in the subject. When last seen in October, 1933, he was definitely better and improved, apparently because of large doses of hyoscine hydrobromide.

CASE III.—M. E., now forty years old, had an acute illness twelve years ago, characterized by twitching of the limbs and difficulty in focusing the eyes. Thereafter, although he returned to his work as a lawyer, he was never the same. The eyes would jump as he expressed it "from line to line." When he came under observation about fifteen months ago he was unable to concentrate in reading, was drowsy all the time, even dropping to sleep while driving his car. Memory was variable. He cannot "think of but one thing at a time." Occasionally he stutters, his writing fades out when he is tired; he is irritable, easily fatigued and tends to be depressed mentally. There are thirst and salivation and twitching of the muscles, sexual potency becoming weak thirteen years after the original attack. Under iodine by mouth followed by caffeine and by strychnine hypodermically he has improved very strikingly.

CASE IV.—N. H., about forty-nine years of age, two years ago, without any pre-

liminary acute illness, became nervous and unsteady in walking; somewhat later he developed headache, vertigo and shaking of the hands when signing his name. At present he complains of being drowsy and is inclined to fall asleep during the day, yet at night he is likely to be wakeful. Four months after the beginning of his trouble, he began to have pains in the legs and a sense of weakness in the left leg, and to tire easily. A little later he had the desire to cry at all times and more recently there has been drooling of saliva in sleep, and loss of potency. Physical examination has shown active knee-jerks but no clonus and a little incoördination in the finger to nose test and in gait. He cannot stand on one foot. The spinal fluid is normal; the Wassermann is negative. While the diagnosis is not definite, nevertheless the course of the disease is strongly suggestive of a subchronic form of encephalitis lethargica.

Case V.—C. W., in February, 1922, when thirty-eight years of age, was taken suddenly ill with headache and dizziness, but was able to continue to play golf. The next day he had pains in the abdomen, left shoulder and left upper arm, diplopia which lasted three or four days, and fever. Two weeks later, the fever continuing, weakness of the right internal rectus muscle appeared; vision was blurred, the pupils small and fixed; the right eye was closed, the left half open; the tongue was tremulous; the hands and body twitched and there was drowsiness interspersed with delirium. This complex picture continued about two months; but the patient for months more continued to be drowsy and to have some twitching of the muscles with weakness and fatigability. He also noticed marked loss of sexual power. Three years later he complained of occasional dizziness and incoördination of gait and loss of control of the right corner of the mouth so that the saliva drooled. There was some astereognosis. The patient has been under my observation from 1922 until the present. His mental powers are practically unimpaired but he continues to be drowsy, has drooling of saliva from time to time and always has a good deal of moisture in the mouth. He is easily fatigued. There is a little lid lag and the eye movements are slow; the pupils are small and react very poorly to light. Last spring he worked very hard and found that his lids would close while walking on the street or while trying to read. It was difficult for him to keep his attention fixed, but on rest he improved decidedly. The impotence continues.

Case VI.—Mrs. M. S. was sixty years old when she was suddenly taken with diplopia and became semicomatous within twenty-four hours. She had fever and delirium and was in bed for several months, but recovered and had no symptoms for a year. Then trembling appeared in the feet, then in the arm; speech and movements became slow; salivation became annoying. There was occasional diplopia and for the past six months there has been dysphagia. Two years later after the patient was first seen—three years after the acute symptoms—her memory was distinctly failing; she had difficulty in keeping her eyes closed, her face was expressionless, saliva dribbled from the mouth, speech was slow, muscular movements very deliberate—an early parkinsonian syndrome.

Case VII.—R. G., a woman, was twenty-seven years old when the disease began in 1924. The chronic symptoms set in two years later. I saw her in 1928. At that time she had a slow gait, slight tremor of the hands and tongue, no pillrolling. The pupils were unequal but reactive to light; the eyeballs would be fixed for long periods, the features appeared ironed out. The reflexes were active and there was no muscular rigidity. I saw her again a few weeks later. She then complained that the eyelids would roll up and that she could not shut her eyes. The turning up of the eyelids would last for hours at a time.

Case VIII.—M. M., forty-five years of age, single, was referred to me by Dr. Peter Brosius of Hazleton, in April of this year, because of tremor of the right arm and fatigability. Several years ago she had an illness diagnosed as a nervous breakdown and spent nearly three months in bed. The symtoms were extreme lethargy, tendency to sleep all the time and a sense of great fatigue; no diplopia. Since then she has not been entirely well but was not aware of anything unusual other than fatigability until toward the

end of 1933. She has been drooling saliva over her pillow at night since that time. In September, 1933, a tremor began to be noticeable in her right hand and arm. It gradually interfered more and more with her typewriting and finally she had to stop. There has also been a slight failure of memory. Her face is somewhat expressionless; she winks seldom and her eyes even feel stiff. She has a feeling as if they were twitching. Without going into further details the patient is now in a state of parkinsonism nearly eight years after an illness which undoubtedly was acute lethargic encephalitis. Under hyoscine hydrobromide her tremor has improved decidedly and she felt that she was progressing nicely until she fell downstairs May 3 and broke her right clavicle. Since then she has relapsed to some degree.

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PSYCHOSIS FOLLOWING CATARACT OPERATIONS*

REPORT OF THREE CASES

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Delirium following surgical procedures was first recorded in the seventeenth century. With modern methods of anæsthesia, care of patients, *etc.*, the frequency has been greatly reduced until now mental disturbances sufficient to attract attention do not occur more frequently than once in every four to six hundred operations in general surgery. It has, however, often been noted, and commented upon, that the frequency is much greater following eye operations, the ratio being about one in every two to three hundred cases. The mental disturbances are variable, often being only a confusion, marked by disorientation and a mild delirium, and occasionally attacks of maniacal excitement. Though the eye is a part of the cerebrum, developed from the primary cerebral vesicle, it is remarkable that symptoms referable to the eye or hallucinations of sight rarely occur. The onset is usually about the third or fourth day following the operative procedure, and may occur either at night or in the daytime. Many theories have been advanced for its causation, but because it usually disappears after proper elimination, return of the patient to his home and successful result of the surgical procedure, not much attention has been given the subject in recent years.

Dupuytren,[1] in 1819, was the first to direct attention to this phenomenon, reporting twenty-one cases of cataract operation in which two showed delirium. In the next one hundred years, about twenty-nine papers were written on this subject. In 1863, Sichel[2] wrote a paper in which he reported eight cases, and he attributed the closure of the eyelids and loneliness to be the precipitating factors.

In 1878, Schmidt-Rimpler[3] reported several cases in which he believed darkness was the cause of the mental phenomenon, as his cases developed in patients confined without light when no operative procedure was undertaken. Schnabel[4] reported 183 operations from the Innsbruck Clinic of which twelve showed psychotic manifestations.

Dr. G. E. de Schweinitz[5] reported in 1900 a series of eighty-six successive cataract operations at the Philadelphia General Hospital, in which two developed mental symptoms. A recent personal communication to the writer states that the condition must be rare, as he recalls no further cases of this kind in his long and extensive practice. The same year, William Campbell Posey[6] reviewed the literature and reported twenty-four cases of delirium

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of the same character. Morton E. Brownell reviewed the cases from the ophthalmological clinic of the University of Michigan occurring during the years 1904–1917. Of these, there were 962 of whom 3.1 per cent. showed evidence of mental disturbance. The average age was seventy-two and one-half years. These patients had all had careful pre-operative medical study, and it was noted that in at least half of them it was possible to predict in which ones delirium was likely to develop. The mental disturbances were marked irritability, restlessness, purposeless movement of the hands, and incoherence.

Whatever symptoms occur in the post-operative period are, however, usually of a passing nature, and can rarely be considered a true psychosis. Three cases, however, have been admitted to Friends Hospital since 1924, in which a definite mental illness occurred whose precipitating factor appears to be related to the operation upon the eyes.

CASE REPORTS

Case I.—F. H., 5531. F. K. P., admitted May 16, 1924, was a fifty-six-year-old housewife. Two operations for cataracts had been performed several months before. Since that time she had become anxious and depressed. She believed that the surgeon had put something in her eye which would permanently impair her vision. She had become self-centred and hypochondriacal. Her husband had been ill with pneumonia in an adjoining room at home, and she thought people were trying to give her the disease. She would awaken in the night with crying spells. She saw a curtain over the door where none was present. She would ask to have poison given her, but she made no attempt on her life because she feared the hereafter.

She was one of seven children. Had married at thirty-three years, and had one child. She was described as being of a sensitive nature, but showing no mental symptoms, very careful of money, but lacking the ability for system in her work. A paternal uncle was said to be "queer" and a sister was in a sanitarium. Otherwise the family history was negative for any neuropathic or psychopathic traits. It was of interest that the last four generations of women had had cataract.

On physical and neurological examination no abnormalities were found. The facial expression was one of distress. The heart was regular, rate 70–80, blood-pressure 125/65. The urinalysis showed albumen on one occasion, and hyaline casts on two. A special eye examination showed that the pupils reached almost to the edge of the iris. The retina of O.S. was clear, the retina of O.D. was deeper in color, and showed several crossed bands, making an interlacing effect. The patient described a ball that floated before the eye, and particularly obstructed her vision. The findings would seem to offer a physiologic explanation of this.

During her course in the hospital, the patient, who was admitted on a voluntary basis, was coöperative. She appeared to have considerable insight. She stated that she was unable to keep her promises at home to remain in bed, *etc.* She was agitated, she tired easily, was worried and self-centred. On several occasions she vomited. She always associated this with the medicine which had been put in her eye, at the time of her operation, saying that it poisoned her. She spoke of kaleidoscopic patterns on the wall, and said that things moved. She explained this as due to her glasses. She had phobias, "something will happen." She was suspicious, tearful at times, but her emotional tone was always consistent with her train of thought. On one occasion she crushed and threw away part of a pill, and later confessed, expressing regret at her behavior. She would refuse to eat, and then ask for food, saying she did not understand why anyone would not eat at the proper time. Although she appeared to be

nervous and agitated in the morning for some time, she continued to improve, learned to disregard the bands in front of her eyes, became interested in her environment, and nineteen days after admission, was free from somatic delusions.

A recent follow-up states that the patient's condition is such that no abnormal symptoms would be noted for some time, but she has apparently shown a complete change of personality, has no affection for anyone, and shows a distinct paranoid trend. Before her illness she was sociable and friendly; but now has had disagreements with her relatives and neighbors, and has withdrawn from church activities. She has become very miserly.

CASE II.—F. H., 6041. S. N. P., admitted January 20, 1928. A sixty-four-year-old undertaker whose family history showed no neuropathic nor psychotic trends. At forty-five years he had had a mild attack of typhoid fever, and at fifty-eight, had been critically ill with pneumonia. He was fond of fishing and gunning, a very cheerful person, and had a host of friends. Although he took an occasional glass of wine or whiskey, he was not addicted to its use, and could in no sense be considered alcoholic.

For the past two or three years, cataracts had been slowly developing, and for one and a half years, he had not been able to read. Recently a portion of an estate which he was to have inherited was left to a nephew. This had humiliated him. Once he remarked that it was such experiences that made "people jump off bridges," adding that he would never commit suicide.

November 16, 1927, the patient had an iridectomy at the University Hospital. The operation was wholly uncomplicated. On the second day he developed hallucinations which became more marked, and the surgeon permitted him to go home sooner than usual, thinking that these would clear up. He seemed somewhat improved in the next two weeks, but the progress was very slow. A psychiatrist was consulted, who believed that the patient was suffering from a psychosis resulting from the operative procedure. After his return home he was unable to tell where he was. He talked about seeing animals, as horses, dogs, heifers, *etc.*, in his room; then he would carry on a fairly connected conversation. About one week before admission he became resistive and uncoöperative. He tore his clothing, bedding, *etc.* For four days he had refused to take any nourishment, saying that it was poisoned. He used profane language, which was entirely foreign to him.

He was very restless and confused, and did not comprehend the simplest commands. He was completely disoriented, and could hold no connected conversation. His remarks were rambling. He was resistive and crawled about the room. To prevent exhaustion, it was necessary to use restraint. For one month he presented the picture of an acute mania. Occasionally there was a slight weakness of the left side of the face, the left knee-jerk was slightly exaggerated and the abdominal reflexes on the left were slightly less than on the right. Lumbar puncture showed four cells per cubic millimetre, negative globulin reaction, and the Wassermann test was negative in all three antigens. A few casts were seen in the urine, but there was no albumen, nor any indication of cardiorenal disease.

Eighteen days after admission he recognized the names of people whom he knew, and one month after his admission, he recognized his family. From this point his recovery was rapid. Following this procedure, he had no recurrence of any mental symptoms. He returned to his home May 30, 1928, entirely restored in so far as any mental symptoms could be detected. He continued well for three years, and died from the effects of the anæsthetic when an operation was attempted upon the other eye. It is noteworthy that as this patient recovered, he recalled with great detail and much emotional reaction all the circumstances regarding his operation at the University Hospital. In the first place, with regard to his work as an undertaker, he had many distorted ideas of hospital life. He recalled bitterly that he did not like the room he had, and that they left him on the operating table alone for a very long time. He also

said that he dreaded the operation—"I was scared. I knew it was going to make me crazy."

CASE III.—F. H., 6313. J. S. M., admitted January 12, 1930, was a seventy-year-old spinster. She was one of seven children. The patient is described as having been cheerful, calm, very happy with her family, and always careful of money. She is said to have been rather nervous and not as active as her brothers and sisters. Seven years before admission she had a carcinoma of the breast removed, followed by X-ray treatment, and there has been no evidence of recurrence. For ten years she had had tremors of both hands and chin. During the last four years she has been losing her eyesight and for the past year has been very anxious for an operation. She was operated upon December 4, 1929, under local anæsthesia. Nine days later a severe iritis developed, followed two days later by hæmorrhage. The following week she had a severe attack of abdominal pain, when a possible diagnosis of mesenteric thrombosis was entertained. Three weeks after operation she complained of severe pain in the right side of her head, and there was a partial paralysis of the entire left side of the body, including the face. She became irrational, and was disoriented as to person and place. She called for various members of her family, and for her grandmother. She again became lucid, and was about to be taken home, when the abdominal pain returned. With this she was much more irrational, cried and screamed. Her blood-pressure remained constant, 140/80. She was very deaf. Urinalysis showed an occasional cast and a trace of albumen.

On admission to this hospital she was very confused, restless, and there was a loud, muttering delirium. She was very difficult to control. This was aggravated by her inability to hear. She was irritable, depressed, anxious, petulant, and wholly disoriented. She showed marked fluctuations of mood, but after about ten days began to sleep and became more quiet. She continued, however, to be disoriented and complained bitterly of headache, saying that horses were stamping on her head. Twelve days after admission there was no apparent local weakness. She was taking nourishment much better than on admission. As she improved, her innumerable somatic complaints continued, and she was very faultfinding and exacting. She fabricated considerably, and complained of neglect on the part of the nurses and physicians. However, she gradually improved and five months after admission had reached her normal condition. She was taken home by her family, and there were no further evidences of any psychosis up to the time of her death, three years later.

We have then three patients whose respective ages were fifty-six, sixty-four, and seventy years, who developed psychoses of severe grade following operations upon their eyes. None of the patients showed evidence of senility or had any marked arteriosclerotic or cardiorenal disease. None was alcoholic nor had had any previous mental illness. In no case was there an important hereditary factor. The duration varied as follows: eight months, three months, and five months respectively. None showed a second psychosis. In the first case, a marked change in personality resulted which, however, was not of sufficient gravity to require the removal of the patient from her home. One patient was markedly hypochondriacal, both before and after the psychosis, while the third, whose psychosis was of the most maniacal type, appeared to be completely restored. In only one of the cases was the operation in any way complicated, but in this one there was iritis followed by hæmorrhage. All of the patients have been sufficiently studied from a medical standpoint to eliminate any serious physical disorder. Upon the basis of these facts, it would seem that we were justified in considering a

psychogenetic factor as the basis in each case. An operation, whether minor or major, is an unusual event in the daily routine of most individuals, and is always surrounded by more or less emotional experience, although evidence of this may be greatly suppressed. While this statement is true in a general sense, it is particularly true in any operation concerning the eye.

To a blind person the hope of restored eyesight is of great emotional as well as intellectual importance. The surgeon impresses the necessity for quiet, possibly even thoughtlessly threatening the restless patient during operation with loss of opportunity for regaining his vision. The hospital environment is to the patient a new and fearful world, with no understanding friend at hand. Far too often the personality of the patient is forgotten in the interest of the case. The custom of placing the patient in a darkened room in many cases without a nurse, either before or after the operation, is, at best, an unhealthy mental atmosphere. These patients are not young; degenerative changes in blood-vessels render the necessary vascular adjustment through the autonomic (sympathetic) nervous system less facile. While not definitely psychotic in the previous years, they have accumulated many phobias and worries with which to weave a psychosis.

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OCCLUSION OF THE CENTRAL ARTERY OF THE RETINA

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This paper will deal principally with the combination of endarteritis and thrombosis as etiological factors in the production of occlusion. Although occlusion of the central artery of the retina is not an infrequent accident, the mechanism of its occurrence is always interesting. It may result from (a) embolism, which could consist of any solid substance that has gained entrance to the vascular system, usually coming from the heart itself; (b) it may be due to thrombosis, usually at a bifurcation of a vessel just back of the lamina cribrosa; (c) it may arise from an arteriosclerosis or endarteritis of the vessel wall; (d) it may be caused by a combination of endarteritis and thrombosis, a condition which is possibly more frequent than is supposed; (e) it may be produced by a spasm of the vessel wall. It is probable that underlying all the above-mentioned causes there is a disease of the wall of the artery.

Gordon and Gresser[1] offer the following similar and additional causes of obstruction of the central artery; (a) embolism, (b) thrombosis, (c) endarteritis, (d) compression of the artery within the trunk of the optic nerve by a hæmorrhage or an inflammatory process, or from without the trunk of the nerve by a tumor, (e) spasm, (f) injury causing a break in the continuity of the artery, as seen in fracture of the frontal region of the skull. In adults occlusion has been associated with arteriosclerosis, apoplexy, nephritis and lues.

Villard, Dejean and Temple[2] believe the central retinal artery is subject to atheromatous changes from which proliferating endarteritis may arise. An interesting collection of microscopical slides of cases of closure of the central retinal vessels were studied by Hippel and Kiel.[3] In one case they demonstrated that the clinical picture of occlusion with optic atrophy, narrowed vessels and complete blindness, could result from arteriosclerosis of the central artery.

In two hundred post-mortems Bridgett[4] described the histological findings in the central retinal artery. The vessel was normal in 45.5 per cent. of the cases. Arteriosclerosis proper was present in 26 per cent., while excessive physiological thickening was observed in 21 per cent. Sclerosis of the central artery was seen one-third as frequently as sclerosis of the aorta, coronaries and cerebral arteries; but sclerosis of the central artery was found in 18 per cent. of the cases in which the aorta, coronaries and brain arteries were macroscopically normal. Fuchs[5] in a post-mortem study of patients over seventy years of age, with special reference to the blood-vessels, found

on histological examination that in no case were the internal carotid and the ophthalmic arteries or their branches normal.

Frost[6] stated that in hereditary lues a hyaline thickening of the retinal vessels, including the central artery, occurs which encroaches on the lumen, gradually narrowing it. This may lead to complete obliteration. Dejean[7] reported a case in which, following two attacks of angina, transitory blindness affected the right eye. After a third attack vision was permanently lost in that eye. The author believed that spasms were present first and finally obliteration of the artery resulted from sclerosis.

In Collins and Mayou[8] we find the opinion that, if the main artery of the retina is obstructed, total blindness results; if a cilio-retinal artery is present, that part of the retina supplied by it retains its function. A portion of the temporal field may also retain perception for a time when the nasal periphery of the retina derives its nutrition mainly from the choroidal vessels. Obstruction to the circulation most commonly occurs behind the lamina cribrosa partly because the vessel becomes constricted at this point and also because the vessel bifurcates in that region. Abelsdorff,[9] in a case of optic nerve atrophy, found on histological examination a complete occlusion of the central retinal artery due to a proliferation of the endothelium at the point of entry into the optic nerve. Engelbrecht[10] made a histological examination of the left eye of a man fifty-nine years old who, four days before, had shown a typical picture of an incomplete stoppage of the central artery. He found an obstruction behind the lamina cribrosa. From a histological study of five normal and six pathological cases, Scheerer[11] concluded that proximity of the central artery and vein to one another at the lamina cribrosa may produce thrombosis provided the artery is sclerosed. In another study of cases of occlusion of the central retinal vessels, Scheerer[12] decided that (a) canalization did not occur, but the vessels in the occluded area were used for the formation of collateral circulation; (b) in every case of occlusion there was found an obliteration of the normally extensive vascular system of the lamina cribrosa, also obliteration of the lymph system, existing between the central vessels and the central connective tissue column, was present.

Lerner[13] inferred from his case of obstruction of the central artery of the retina that, in advanced years, endarteritis with thrombosis is usually the cause of the occlusion. According to Boycott[14] arteries are commonly obstructed from within and the active overgrowth of the vessel wall itself often leads to a complete obliteration, as in syphilitic endarteritis, but not to total closure unless clotting (thrombosis) is superadded. Old sclerotic vessels have little capacity for adjustment and dilation.

In the opinion of Roemer[15] occlusion of the central artery is more often caused by thrombotic processes in the artery excited by degenerative changes in the walls, than by embolism. In most cases the obstruction is due to a primary endarteritis of the wall of the artery, in which the lumen is constricted by progressive proliferation of the intima. To differentiate between

embolism and endarteritis we first note whether there is any refilling of the vessel soon after occlusion, as frequently occurs when a retrogression of the endarteritis causes a partial restoration of the circulation. According to Kern[16] no cause for an embolus can be found in about 66 per cent. of cases, so that a local disease in the artery is probable in a great majority of instances. Endarteritis obliterans may be diagnosed when one is able to see, immediately after the occlusion or at a later time, that the wall of the vessel is diseased. This was true in the case below reported.

Roemer further states that the clinical course of this phenomenon depends upon the cause and duration of the occlusion of the vessel and varies accordingly. Obstruction of the central artery usually results in total blindness, but cases occur in which the sudden blindness disappears and is followed by a high degree of amblyopia, or even normal vision may return. In such a case sufficient space is left by distention of the vessel to allow blood to return and restore the function of the retina. Some cases of partial restoration of vision are due to the presence of a cilio-retinal vessel, as noted before, or a branch of the central artery may be given off above the point where the blocking begins.

The most frequent causes of obstruction of the central artery of the retina according to deSchweinitz[17] are valvular heart disease, especially if complicated by fresh endocarditis, general arteriosclerosis, aneurism of the aorta or carotid, Bright's disease and pregnancy.

A few cases have been associated with chorea, menstrual disorders, anæmia, recurring epistaxis and diabetes. According to Arnold Knapp it is impossible to find the cause in about 30 per cent. of the cases.

The prognosis is unfavorable in the majority of cases.

Treatment may consist of sclerectomy, iridectomy, repeated paracentesis of the anterior chamber, massage and inhalation of amyl nitrite. Young[18] reported a case in which he used 2 per cent. pilocarpine followed by vigorous massage with beneficial results.

Case History.—Mr. F. E. S., aged 61 years, consulted me on November 22, 1929, for a refractive error. At this time his disks were well defined and of good capillarity. His retinal vessels were markedly sclerosed with deep indentation of the veins where crossed by rigid arteries. His vision in each eye was 6/20 corrected to 6/5. At this time the patient was warned not to overwork.

Four years later, on January 8, 1933, while jumping out of an automobile, in a rush to catch a trolley, he came down heavily on his right heel, jarring himself considerably. Immediately afterward, while on the trolley, he noticed the vision of the right eye was obliterated down within about nine inches of the ground. Gradually the vision improved so that within an hour he could vaguely see whole objects but they appeared blurred. He came to my office the following morning, January 9, 1933, when he said the vision in the affected eye was slightly less blurred than the day before. It was 3/40 corrected to 6/40. Vision in the left eye was 6/30 corrected to 6/7-3. The patient said he had been working very hard and was under a nervous strain.

Ophthalmoscopical examination under euphthalmine revealed the following in the right eye. Media were clear. The disk was well defined, but slightly pallid. The main trunk of the central artery was dead white as it came out of the physiological cup,

while the nasal branches extending for about 1 d. d. distance off the disk and the macular branch extending to the edge of the disk, were also white, resembling blanched cords. The remaining vessels were markedly sclerosed with indentation of veins. The macula was slightly fluffy in appearance, but no cherry red spot was present. The left fundus presented no abnormalities, beyond the sclerosed vessels. Digital massage for, from five to ten minutes T.I.D., was prescribed. On January 19, 1933, his vision had improved from 3/40 to 6/30 without correction and 6/7 with correction. On this date the macular branch was filled with blood and there were streaks in the nasal branches. Fields taken on January 9, 1933, showed a slight peripheral contraction with a slightly enlarged blind spot.

At this time the patient decided to take a sea voyage to the Holy Land. While at Cairo he had an anginal attack and another one at Beirut, at which latter place he spent several days in the hospital and was examined by the physician in charge, who said he had hardening of the arteries affecting his brain, and that a stroke might be looked for in the future. His blood-pressure was $\frac{200}{120}$. The patient returned home immediately, but during the journey to New York it was necessary to guard him closely as he had spells of wanting to commit suicide, disorientation and sudden bursts of temper. For years he had had nocturia two or three times a night. He was admitted to a hospital on May 3, 1933, where he was thoroughly studied.

One internist found a mitral systolic murmur, which he thought was functional; also there was present a chronic prostatitis which, according to the urologist, was causing the upset. From a neurological standpoint his condition was thought to be psychical and not due to an organic disease. A second internist however believed the patient's condition was due to arteriosclerosis of the brain and prostatitis. A series of prostatic massages were done and the vas deferens was ligated. Immediately after the operation the patient's temperature rose to 102, pulse was elevated and he became delirious. He recovered sufficiently to get out of bed and two days following his last prostatic massage he was allowed to go to the bathroom. He suddenly collapsed and died within a few minutes. Cause of death was diagnosed as pulmonary embolus.

Laboratory Findings.—May 4. Urine and spinal fluid negative. The culture of the secretion from the prostate showed pseudodiphtheria bacilli. An X-ray of the patient's chest did not appear abnormal in size or outline. The aortic arch was tortuous, the result of hypertension. May 12. Urine showed a slight trace of albumen, with a few hyaline and light granular casts and an occasional leucocyte. Specific gravity was 1020. There were present in the prostatic culture, Bacilli of Hoffmann, Staphylococcus albus and colon bacilli.

Autopsy.—The body was that of a well developed white male of sixty-five years. On removing the calvarium, nothing noteworthy was seen on the cortical surfaces. At the base, the carotid arteries were very stiff and gaping. The vertebrals showed an atheromatous condition. On opening the chest, each plural cavity was found free of adhesions and fluid. Section of the lungs showed several small fibrotic areas, with caseous centres, in the middle lobe of the right lung near the hilum. On opening the pulmonary arteries they were found completely occluded by well formed and laminated thrombi.

There was slight scarring of the aortic valves at their bases. The coronary arteries appeared stiff and gaping. There were numerous atheromatous plaques present in the arch of the aorta.

The prostate was normal in size and consistency. There were two or three small nodules present in the gland.

Microscopical Examination.—Heart.—There was a diffuse increase of connective tissue throughout the myocardium. In many places the muscle fibres were completely replaced by connective tissue. The intima of the coronary arteries was thickened.

Prostate.—There was some glandular hyperplasia. Many of the acini were filled with fluid and a few contained polymorphonuclears. There was some round-cell infiltration around the acini. There was an increase of connective tissue in the muscularis.

Summary and Comment.—A case of occlusion of the central retinal artery is reported in a man sixty-five years of age, who had been under a severe nervous strain. The onset was preceded by a heavy jolt, while alighting from an automobile. We find from the literature that the favorite site for occlusion of the central artery of the retina is in the neighborhood of the lamina cribrosa. This condition is more apt to occur in sclerosed vessels, especially when there is a bifurcation of the artery just back of

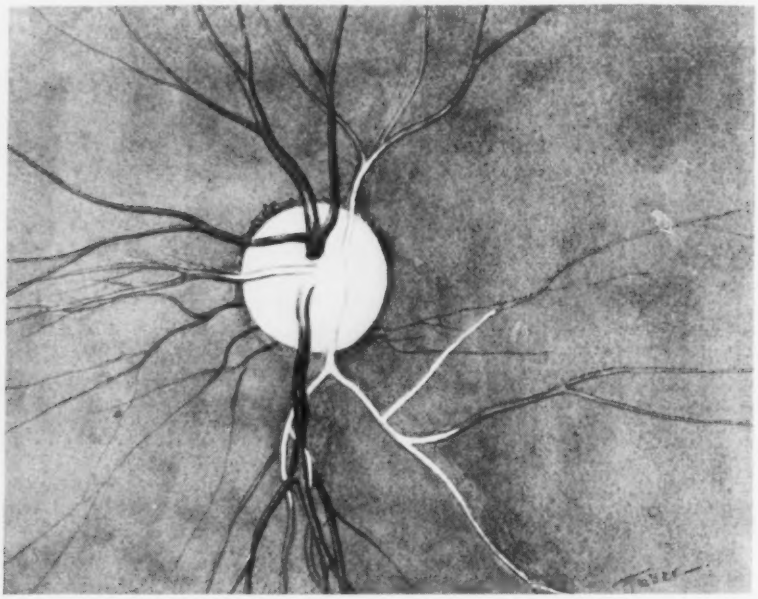

Fig. 1.—Occlusion of central artery of the retina.

the lamina. An added factor to the sclerosis, which makes the occlusion more of a certainty, is a thrombus. In the case reported, there were the post-mortem findings of markedly sclerosed basal vessels of the brain, including the carotids and it is natural to suppose that the ophthalmic, a branch of the internal carotid, would be equally sclerosed, particularly since there was direct ophthalmoscopical evidence of endarteritis obliterans of its branch, the central retinal artery. As the eyeball with the accompanying nerve and ophthalmic artery were not procured, we cannot present the absolute evidence of a thrombus, but the cases of other writers and the fact that thrombi were found in other parts of the body lend weight to the assumption that there was a thrombotic process in the ophthalmic artery of the right eye.

Judging from the small amount of pathology found in the prostate one would not suppose that this gland had any connection with eye condition,

although it cannot be entirely ignored. The effect of the series of massages may have had some bearing on the thrombi present in the lung.

CONCLUSIONS

1. Arteriosclerosis of the cerebral vessels and their branches is usually present in cases of occlusion of the central artery of the retina. Add a thrombus to the foregoing and we have a complete picture in a majority of the cases.

2. It is logical to expect the return of at least a small amount of vision in this condition, as was noted in the author's case.

3. Digital massage appeared to be of benefit in restoring partial vision in this instance.

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THROMBO-ANGIITIS OBLITERANS IN WOMEN

REPORT OF TWO CASES

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The almost exclusive occurrence of a widespread disease in a single sex is a curious and provocative fact. While predominance of certain diseases in one or the other sex is well known, such as the greater frequency of Graves' disease in the female and peptic ulcer and coronary artery disease in the male, the exclusive occurrence of an ailment in one sex is confined to the hereditary sex-limited conditions such as hæmophilia and color blindness. In the latter conditions the hereditary nature of the disease is clearly defined. Transmission is through the female, who only rarely and under exceptional circumstances may show the presence of these ailments.

Thrombo-angiitis obliterans presents the unique picture of a disease which is not by any means rare and which is limited with very few exceptions to the male sex. It has been my opportunity to study over a thousand cases of this disease, and yet only twice have I seen the condition in women.

The infrequent occurrence of the disease in the female has been noted by other observers. Thus, Buerger[1] cited only two instances in women in a series of five hundred cases studied by him and Willy Meyer[2] reported he had never seen a female with this condition. In December, 1932, Horton and Brown[3] reported the experience of The Mayo Clinic, and stated that in seven hundred cases ten examples of the disease had been seen in women. The impression gained from a study of their reported cases is that they regarded as thrombo-angiitis obliterans instances of senile gangrene, arteriosclerosis associated with hypertension, and Raynaud's disease. The presence of superficial phlebitis in the legs without closure of arteries is not sufficient evidence upon which to establish the diagnosis of thrombo-angiitis obliterans, even when biopsy of such veins shows the inflammatory lesions described by Buerger. It has not been demonstrated that such lesions are found only in this disease. In reporting so rare a condition as thrombo-angiitis obliterans in women it is desirable to avoid the inclusion of doubtful cases. While this may diminish the number of cases reported, it gives a more accurate impression of the infrequency of the disease in the female. Judged by more rigid limitations not more than five of the ten cases reported from The Mayo Clinic appear to be true instances of thrombo-angiitis obliterans in women. In three of these the use of tobacco was recorded. To this list should be added one case reported by Meleney and Miller[4] in a Chinese woman of forty-eight years who was not a smoker, and one case by Durck[5] in a young woman of twenty-seven years who was a heavy smoker.

The two instances of thrombo-angiitis obliterans in women observed by the writer may be briefly summarized as follows:

CASE I.—H. B., aged twenty-nine years, American Hebrew, was in perfect health until August, 1931. While walking out of the water at the beach she felt pain in her left leg which was so severe that she was unable to walk for an hour. She limped home and following this episode continued to have intermittent claudication in her left leg after walking three blocks. In December, 1931, she was treated by a chiropodist for an ingrown toe nail. Gangrene of the left big toe nail associated with severe pain developed. This extended and involved the first and second toes and an extensive portion of the dorsal surface of the left foot. Owing to severe pain, nerve section to produce anæsthesia of the involved area was carried out. Following this, amputation of the first and second toes was done. In the course of time a granulating wound formed and the foot healed completely and has remained healed up to the present time.

This patient had smoked twenty cigarettes a day for a number of years but discontinued smoking with the onset of the present illness. She has been married nine years and has two healthy children. There were no complications of any kind with her confinement and nothing in the history to suggest an embolic disease from any source. Her menses are regular but scant, usually lasting one or two days. She suffers with hay fever in August and September, due to ragweed. The family history is entirely negative for vascular diseases in the extremities. Her father had asthma as a young man.

Examination in December, 1933, shows a perfectly normal healthy young woman with the exception of the condition in the lower extremities. The circulation in the upper extremities is normal. The left femoral is open. The left popliteal is closed. There is no pulsation in the left foot. All normal pulsations are present in the right foot. The left first and second toes are missing and there is a well-healed scar over this portion of the foot. The oscillometer readings at the left calf—1½, left ankle—very faint, right ankle—2¼. The basal metabolism is minus eleven. Blood volume is 63 cubic centimetres per kilogram. Chemical examination of the blood reveals that cholesterol is 250 and calcium is 12. Skin tests show sensitivity to tobacco, ragweed, and timothy.

CASE II.—M. S., aged thirty-three years, American Hebrew, has had attacks of superficial phlebitis on the right leg during the past six years. There have been three such attacks and evidence of the last one is still present. Five weeks ago the left big toe became swollen and painful. The pain is worse at night. For the past five years there has been some discomfort in walking. Patient suffers with hay fever every August. There is no history of any other serious illness. Her menses are regular, usually lasting two to three days. Patient has been smoking fifteen cigarettes a day for the past seven years. There is no history of vascular disease in patient's family.

Examination reveals a perfectly healthy young woman with the exception of the extremities. The radial vessels are open on both sides. The ulnar vessels are not felt on both sides and the Allen test is confirmatory of obstruction in these vessels. Both femorals and both popliteals are open. No pulsation is felt in either foot. The right foot shows marked rubor in the dependent position and striking pallor on elevation. There is evidence of recent phlebitis on the inner side of the left ankle. The tip of the right big toe is tender and there is a fissure at this point. The oscillometer readings are left calf—4½, left ankle—1½, right calf—3, right ankle—¾. Skin tests showed sensitivity to tobacco and ragweed.

COMMENT.—The significant clinical facts in both cases are the youth of the patients (twenty-eight and thirty-three years), the Jewish ancestry, the use of tobacco, the presence of occlusion of major arteries in the lower extremities, and the evidence of sensitivity to tobacco by skin tests. In the first case the blood volume was low, the basal metabolism was reduced, and an elevated calcium and cholesterol was present in the blood. We have found

these changes characteristically present in thrombo-angiitis obliterans.[8, 9, 10] In the second case the diagnosis rests on the history of migrating phlebitis in the legs associated with the presence of closed arteries and characteristic postural color changes in the involved foot. Unfortunately we had no opportunity to carry out laboratory studies in the second case. There is no family history of thrombo-angiitis obliterans in either case.

Discussion.—Evidence that there is a constitutional hereditary factor in thrombo-angiitis obliterans is still meagre. The greater predominance of the disease in Hebrews is striking, although in recent years this racial limitation has become less apparent. Even at this time, however, in proportion to the population, the incidence of thrombo-angiitis obliterans in Hebrews is much greater than in any other nationality and such a racial preponderance would appear to indicate an hereditary constitutional factor. The ailment occurs in brothers with a frequency which is possibly slightly more than that which one might expect as being due to pure coincidence. I have observed the disease in brothers eight times. Three instances in brothers are reported by Samuels.[6] I have had the opportunity to examine adult sons of three men who have had thrombo-angiitis obliterans. In no case was any evidence of the disease present in the sons. I have seen one patient with thrombo-angiitis obliterans whose father was Italian and whose mother was Jewish. Since the disease is so much more frequent in the Jewish race, whatever hereditary factor one may surmise is present would in this instance appear to have been transmitted from the mother. The evidence cited above is undoubtedly scanty and data suggesting inheritance along Mendelian lines is lacking.

In an attempt to study the question of inheritance of a constitutional factor through the mother a study was made of the blood grouping of individuals with thrombo-angiitis obliterans and their parents. This was undertaken because it was felt that if blood grouping of the patient invariably was the same as the blood grouping of the mother the establishment of this fact might be of significance. We were aware that no evidence exists that blood grouping is inherited along sex-linked lines. The results of this investigation showed that the blood grouping of patients with thrombo-angiitis obliterans is as frequently similar to the father as to the mother and therefore no conclusions could be drawn from this study.

It must be borne in mind that the hereditary factor which influences tobacco sensitivity, if one is present, is only brought out when the patient uses tobacco. It is therefore possible that it may be latent in many more individuals than is realized, but because they do not smoke they do not manifest signs of the disease. I know that in taking the stand that thrombo-angiitis obliterans never occurs except in those who smoke, I am not in complete agreement with other observers. My explanation of this difference of opinion is that those who report thrombo-angiitis obliterans in non-smokers are not careful to exclude other forms of vascular disease, particularly true pre-senile arteriosclerosis. In reporting thrombo-angiitis obliterans in non-

smokers, just as in reporting this disease in females, scrupulous care should be taken to exclude all doubtful cases, so as to avoid confusion. The most important single clue we have as to the nature of thrombo-angiitis obliterans lies in its invariable relation to the use of tobacco. If we obscure this fact by careless observation and report, we merely add to the confusion and mystery surrounding this important disease, and hinder progress toward a true understanding of its nature.

It may be claimed that the apparent immunity of the female sex to thrombo-angiitis obliterans is due to the fact that women are not smokers. Such a claim would have had more weight twenty-five years ago, but it is common observation that in the past twenty years women in increasing numbers have taken up the smoking habit, and there is at present much less difference between the sexes in this respect. If women are truly susceptible to thrombo-angiitis obliterans, by now the incidence of this condition in the female should be much greater than nine times in twenty-two hundred cases. Since thrombo-angiitis obliterans frequently is clearly apparent in individuals who have smoked only a few years, ample time has now elapsed for many cases of this disease to have developed in the female, and its relative rarity is striking.

The work of Harkavy[7] in demonstrating positive skin reactions to the injection of tobacco protein extracts in these patients tempts one to assume that thrombo-angiitis obliterans may be an allergic disease. However, here one also meets the objection that no known allergic diseases are confined to one sex.

CONCLUSIONS

Two cases of thrombo-angiitis obliterans in women are reported. The significance of the rarity of the disease in the female is discussed.

While the evidence is as yet inconclusive, the striking limitation of thrombo-angiitis obliterans to the male sex and the great preponderance of cases in the Hebrew race suggests that there is a sex-linked hereditary factor in this disease. The use of tobacco is an additional essential factor to produce the condition, and potential thrombo-angiitis obliterans cases who do not smoke may show no evidence of vascular disturbance. This hypothesis may account for the lack of more conclusive evidence that the constitutional factor in this disease is inherited.

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BILATERAL PARALYSIS OF THE FACIAL AND ABDUCENT NERVES AS REMOTE EFFECT OF TUMOR OF THE BRAIN

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Paralysis of the abducent nerve with tumor of the brain not directly implicating this nerve has long been recognized, but the corresponding paralysis of the facial and other cranial nerves is not so well known. A case of this character in the service of Doctor Frazier which was studied by me in consultation is reported.

Case Report.—The patient, a woman aged thirty-two years, entered the neurosurgical service November 14, 1931. Right abducent nerve paralysis and left facial nerve paralysis were discovered on November 16. These symptoms probably developed before the patient entered the hospital. The case was presented at the Neurosurgical Conference with the following summary, November 17, 1931.

Chief complaints: Headache, mental confusion, transient attacks of blindness, nausea and vomiting. History of previous illness. Onset in August, 1931, with headache, nausea and vomiting. Five weeks previous to entrance another attack of headache, nausea and vomiting, and a feeling that "her mind had been turned back a thousand years" occurred. Two days later she had dizziness and a fainting spell. About four weeks previously mental confusion was first observed by her husband. It came in attacks lasting an hour or more. Recently the mental confusion increased in severity and now is almost constant. Two weeks previously the headache which had been entirely frontal also involved the occipital region. Within the week preceding entrance the patient had two attacks of transient blindness with nausea, vomiting and headache. The attacks lasted about five minutes. Diplopia and difficulty in swallowing were first noticed November 16, 1931.

In this conference Doctor Frazier made the comment that the mental confusion was so conspicuous that it must be considered as other than mere evidence of pressure. In this he was correct, for the necropsy showed implication of the genu of the corpus callosum by the tumor. On November 28 he found marked astereognosis. This was suggestive of parietal lobe involvement.

Examination by Doctor Spiller, November 18, 1931. The weakness of the right external rectus muscle was distinct yesterday. This morning the paralysis of this muscle is greater. In looking to the right the right eye is moved only slightly toward the right beyond the median line, while the left eye is moved to the full extent toward the right. The tendency to droop the right upper eyelid is even more pronounced than it was yesterday. The patient can at request raise the right upper lid to normal degree, and it is possible she has developed the drooping to overcome the diplopia. Convergence is good with both eyes, but frequently the left eyeball shows a tendency to deviate outward. When my finger is held directly in front of her face, she sees only one finger but when I move it slightly to the right, she immediately sees two fingers and they are side by side, indicative of the weakness of the right external rectus muscle, and as I move my finger to the right the two fingers get wider apart.

I do not detect weakness in either trigeminal nerve, and touch, pain, heat and cold sensations are normal in each trigeminal nerve distribution. I have tried to ascertain whether hearing is affected. I think it is not, and Doctor Winston finds the hearing is good in both ears.

She has paresis of the left facial nerve. In showing the teeth the left corner of the mouth is not drawn up, and there is very little movement in the left side of the

mouth. The left eyelids are not fully closed and the left upper lid may be raised against her resistance with very little effort. The forehead on the left side is not wrinkled when the eyebrows are raised.

The hand test shows distinctly that she has right lateral homonymous hemianopsia, and it also shows clearly that her vision for motion is preserved in a part of the field where vision for form and color is lost. She does not recognize my hand at all in the right fields until I bring it almost to the median line, although she recognizes something moving. The visual fields showing the hemianopsia were accurately determined by Doctor Wentworth.

Finger to nose test shows no incoördination on either side. She does not at times quickly grasp the meaning of what I say on account of mental obtundity. Diadochokinesis is normal in each hand. The grasp of each hand is powerful; I detect no pronounced weakness. Biceps, triceps and wrist reflexes are not distinct on either side. Touch, pain, heat and cold sensations are normal in the upper limbs.

It is not advisable for her to be examined standing or walking as she had a lumbar puncture last evening. Voluntary movement against resistance in the lower limbs appears to be entirely normal. The patellar reflex is not obtained on either side, even with reinforcement. The Achilles reflexes are equal but weak. The Babinski reflex is with distinct flexion of all the toes and is negative in each foot. Heel to knee test is fairly well performed on each side. Touch, pain, heat and cold sensations are normal in each lower limb.

The important findings in the case are paralysis of the right external rectus muscle, incomplete but pronounced paralysis of peripheral type of the left facial nerve involving all its branches, right homonymous lateral hemianopsia, no distinct impairment of the pyramidal tract of either side, no impairment of the long sensory tracts for touch, pain, heat and cold sensations in the trunk or limbs.

Examination by Doctor Spiller, November 29, 1933. The weakness of the left side of the face in the upper and lower distribution of the facial nerve is still present, but is distinctly of less intensity than it was at my previous examinations. There seems to be a little weakness in the lower part of the right side of the face, the right corner of the mouth is not drawn up with quite the power that it has been in previous examinations, and there is undoubtedly a weakness of the right orbicularis palpebrarum muscle, inasmuch as the patient can not fully close her right eyelids but leaves a palpebral fissure about 2 millimetres in width. I cannot detect any weakness of the motor fifth nerve supply on either side. There is undoubtedly now slight paresis of the left external rectus muscle which was not present previously, and the paresis of the right external rectus muscle still persists. The weakness of each external rectus muscle is not a paralysis of associated ocular movements, because in looking to the right the left internal rectus muscle functions, and in looking to the left the right internal rectus muscle functions. It is possible that this moderate degree of weakness in each external rectus muscle is the result of increased intracranial pressure, for probably the pressure has markedly increased, inasmuch, as at the present time the patient has a choked disk of 4½ D. in one eye and 6 or 7 D. in the other eye, whereas, at the former examination she had a choked disk of 4 D. in each eye.

Doctor Frazier noted from the first examination of the patient in this hospital that she did not seem to understand simple commands, such as "put your first finger on your head." I have observed this condition also, but whenever I examined this patient, she was so much under the influence of hypnotic drugs that I felt caution was needed in accepting what seemed to be an inability to understand simple commands. I attributed the results also partly to mental deterioration. On November 29 she had not received hypnotic drugs for twenty-four hours. I tested her then to see whether she

understood what I said. I spoke to her about her children, and purposely gave the wrong number and wrong sex and made incorrect statements. She immediately recognized the inaccuracies of what I was saying and corrected me. I made other tests. She did not comprehend promptly what I asked her to do, but after thinking a moment she usually performed the desired movement correctly. She complained that her mind seemed dull. In these tests she undoubtedly showed no evidence of word deafness. She read three words correctly. Reading was difficult because of hemianopsia. Diplopia also complicated reading. She probably was not word blind. She showed no signs of jargon aphasia. She has never been at a loss to get the exact word she desired in conversation, and the diagnosis of incipient word deafness could not be made.

The right homonymous hemianopsia I attributed to the implication of the left optic radiations by the tumor at the temporo-occipital region. Since the patient has not shown any weakness of her right limbs (the weakness of the right side of the face is not of central type), and has not shown any impairment of sensation in the right half of her body, including the face, the lesion cannot extend far into the internal capsule or optic thalamus. Caution is needed in explaining the weakness, first of the left facial nerve with later improvement, and later of the right facial nerve, by increased intracranial pressure. The facial nerve is resistant often to direct pressure, and I have known it to be distorted much out of its normal course by an angle tumor, when during the lifetime of the individual the weakness of the facial nerve was not very pronounced because the tumor had developed slowly. Cushing[1] also has recognized this fact. He says in cases of cerebello-pontile tumor there may not be the slightest evidence of weakness of the facial muscles unless the condition is far advanced, and yet post-mortem the seventh nerve may be found wrapped around the circumference of the tumor, flattened and drawn out to more than twice its normal length.

Nevertheless, the paralysis of the right abducent nerve and of the left facial nerve, with improvement of the facial paralysis after some days, and later development of paralysis of the right facial nerve and of the left abducent nerve, with almost if not complete integrity of the motor and sensory tracts, led me to conclude that the paralysis of these four nerves might be from remote pressure from the tumor or from increase of intracranial pressure. These findings made involvement of the pons by the tumor doubtful, as a tumor large enough to cause paralysis of both abducent nerves and of both facial nerves must be a large one, unless it implicated the abducent nuclei and the facial nerves as they encircle these nuclei. Such a tumor would be likely to cause some disturbance of the long sensory and motor tracts.

Operation.—Ventriculogram. Local anæsthesia. Perforation of the posterior horns of both ventricles. Right ventricle dilated, left practically collapsed. Operator—Doctor Frazier.

Step 1.—Right ventricle tapped—pressure 320 millimetres water after some fluid had escaped.

Step 2.—Left ventricle tapped.—Throughout the operation only a drop or two of fluid escaped from the left ventricle, always blood-tinged. With the aid of posture, straining, and coughing, and jugular compression, we were able to secure only 21 cubic centimetres of fluid from the right ventricle. It seemed perfectly manifest that the tumor was not of the posterior fossa and must be in the left hemisphere. Five cubic centimetres of air were introduced into each ventricle before the cannulæ were removed, and the wound closed. While the cannulæ were still in place, we could hear a whistling sound in the head which we had never heard before.

Report on the ventriculogram by Dr. H. K. Pancoast, November 30, 1931. Defect or obliteration of the body and posterior horn of the left lateral ventricle, indicating a lesion in the left temporoparietal region.

Comment.—The anterior film shows less air in the left lateral ventricle, and there is a slight mid-line shift toward the right. The posterior film shows very little air in the posterior horn of the left lateral ventricle. The left lateral stereoscopical films show air only in the anterior horn of the left lateral ventricle. There seems to be an encroachment upon the body of the left lateral ventricle. The foramen of Monro on the left side can be seen and appears to be open. The third ventricle is easily seen and seems to be slightly forward. In the right stereoscopical views the right lateral ventricle seems to be intact and not enlarged. The air still remains in the anterior horn of the left. The aqueduct is visible but we cannot find the fourth ventricle.

Operation.—Exploratory craniotomy, left temporo-occipital. Concluded with liberal decompression. Avertin anæsthesia, closure under ether. Operator—Doctor Frazier, November 30, 1931. Flap was reflected to uncover most of the temporal and the adjacent portions of the parietal and occipital lobes. When the flap was reflected the dura was tight as a drum and we realized that it could not be opened without relieving pressure in some way, despite the fact that the right ventricle had been tapped just before the operation. On tapping it again, it contained more fluid and air which upon evacuation did not have much effect upon the pressure.

Before opening the dura it was decided to explore for a gliomatous cyst. This was done at three points as indicated in our cellophane diagram. The third puncture must have entered the ventricle as a few drops of fluid escaped and continued to escape until later it was withdrawn. I decided now not to make any attempt at further exploration unless we could see the tumor at some point on the surface. It seemed inadvisable to make a transcortical incision on account of the increased pressure. Dural incision was made down the middle of the opening from almost the superior margin to the base of the skull and two horizontal incisions on either side. This enabled the flaps to be turned back so that we had a view of all the cortex in the cranial opening. There was no suggestion of tumor at any point.

Just as we were about to close the wound there was a spurt of blood through the cortex which must have come from a subcortical hæmorrhage. A clot about the size of an English walnut was found and evacuated. Bone was removed from the flap and the wound was closed. At one time the blood-pressure dropped as low as 54 and the pulse became quite rapid, but toward the latter part of the operation, after she had received 500 cubic centimetres of citrated blood, her blood-pressure rose and her pulse improved. There was little pressure at the site of the operation after the wound was sutured. Death occurred December 1, 1931.

The macroscopical vertico-transverse sections were examined by Doctor Alpers and Doctor Spiller. The figures refer to the Anatomie des Centres Nerveux by J. Dejerine, vol. 1. Through an oversight this specimen was not described when it should have been. It has been sectioned, so that the following description is based on a reconstruction of the brain and lesion.

There is an infiltrating tumor which involves also the body of the corpus callosum.

These structures are rather markedly enlarged. The tumor is not confined to this area, however, but extends into the adjacent brain tissue.

Fig. 245: Section 63, corresponding to line 63 passing through the knee of the capsule, segments of the lenticular nucleus, and a little posterior to the middle of the island of Reil. This shows a small infiltration of tumor in the callosum confined to the left side.

Fig. 247: Section 69, passing through the posterior part of the anterior fourth of the internal capsule, and the beginning of the optic thalamus shows considerable more extension of the tumor in the corpus callosum and slight extension into the adjacent white matter of the left side only. There is no involvement of the internal capsule at this level. The motor cortex at this level is not involved.

Fig. 249: Section 75, passing a little posterior to the middle of the posterior limb of the internal capsule and the beginning of the posterior fifth of the island of Reil, and through the posterior portion of the paracentral lobule. There is invasion of the left side of the corpus callosum and considerable extension into the adjacent white matter. There may be some invasion of the fibres passing to the anterior portion of the posterior limb of the internal capsule.

Fig. 255: Section 89, passing through the posterior limit of the posterior limb of the internal capsule, the anterior part of the optic radiations and posterior to the island of Reil. Here the tumor and hæmorrhage involve the greater part of the parietal lobe. At this level the optic radiations are definitely involved and this explains the homonymous hemianopsia. There is no involvement anywhere of the left temporal lobe.

There is a small hæmorrhage in the left pulvinar. There is probably tumor tissue as well as hæmorrhage in the parietal and occipital lobes. The cerebral peduncles are not invaded by tumor.

Microscopical description of the tumor by Doctor Alpers designated it as an astrocytoma. The portion of the brain-stem containing the nuclei and intramedullary fibres of the abducent and facial nerves was cut in my laboratory in serial sections. No evidence of tumor growth was found here. The left facial nucleus contained chiefly normal cells, but also a considerable number of cells showing chromatolysis and displacement of the nucleus. The right facial nucleus was more nearly normal. Distinct pathological changes were not seen in the abducent nuclei.

The left facial nerve paralysis was observed November 16th and I noted weakness of the right facial nerve November 29th, thirteen days later. The longer duration of the paralysis in the left nerve probably explains the presence of degenerated nerve cells of the type of reaction at distance in the left facial nucleus, and this degeneration resulted from trauma of the nerve.

Collier,[2] in 1904, showed that local signs appearing late in the course of intracranial tumor, where general signs alone have preëxisted, are often of false portent. He studied 161 cases of brain tumor. In his observation of paralysis of cranial nerves as regards the olfactory nerve, anosmia was found in his series only as the direct result of local pressure from the growth upon the olfactory tract and bulb. Hemianopsia was observed in two cases as remote effect. Paralysis of the third nerve as remote effect occurred in two cases. It was associated with paralysis of the sixth nerve and appeared later than the sixth nerve paralysis. Paralysis of the fourth nerve was not found as an indirect effect of intracranial tumor. He found the fifth nerve affected in two cases, and in both of these tract hemianopsia was present. Both forms of paralysis probably resulted from the indirect pressure of a tumor upon the middle fossa of the same side. In the two cases of fifth nerve involvement the motor paralysis appeared before the sensory paralysis.

He found the sixth nerve paralyzed in twelve cases of supratentorial tumor. The paralysis was unilateral in six cases, and bilateral in six cases. The paralysis of this nerve was more common as an indirect result of intracranial tumor than paralysis of any other cranial nerve. The explanation usually given for this fact is that this nerve has a long intracranial course and therefore is more likely to be affected in general increase of intracranial pressure. Collier rejects this explanation and states that all the cranial nerves attached to the brain stem, with the exception of the sixth pair, are directed transversely or obliquely from their superficial origins to their exits from the subdural space. The sixth pair of nerves are directed straight forwards. The shifting backwards of the brain stem can have little traction effects upon the roots of those nerves, which are directed transversely; but considerable traction effect must occur from such shifting in the case of the sixth nerves.

The seventh nerve showed peripheral paralysis in two cases. It was preceded by a paralysis of the sixth nerves. In one case a large tumor occupied the posterior horn of the left lateral ventricle, and the facial paralysis was on the left side. In the other case a large tumor was situated in the left frontal region, and complete paralysis of the left seventh and eighth nerves occurred. Collier mentioned that slight weakness of the lower face is of common occurrence in supratentorial tumors of any situation. He offers no explanation for this. This form of weakness is not of peripheral type.

Bone deafness was present in two cases, in one case it was associated with paralysis of the seventh nerve, in the other case it was without this paralysis. The ninth, tenth, eleventh and twelfth nerves were not directly affected in any of the cases. He finds that paralysis of cranial nerves as an indirect result of intracranal tumor is not of very common occurrence.

The following remarks were made by me[3] and published in a paper in 1910. "General symptoms may be mistaken for focal symptoms, and this is especially liable to occur if the supposedly focal symptoms appear late. The early appearance of focal symptoms has much greater diagnostic value than the appearance of the same symptoms after intracranial pressure has been increased for some time. Nerve deafness occurring with other signs of tumor has been regarded by almost all as of focalizing value. If it develops late in the symptom-complex there is a possibility that it may be merely a sign of intracranial pressure, and comparable with papillœdema. Some evidence is at hand to indicate that possibly early appearing nerve deafness may be from general intracranial pressure, as in a case reported recently by Ruckert, in which tinnitus aurium and nerve deafness were among the first signs of tumor of the frontal lobe. Internal hydrocephalus may be used to explain certain cases of this character, or pressure driving the posterior part of the brain into the foramen magnum. It is well perhaps to be a little cautious in regardng nerve deafness as one of the general symptoms of intracranial pressure; it is far more frequently a focal symptom, and not entirely parallel with papillœdema.

"Other cranial nerves may be affected by general intracranial pressure, but the signs of such involvement are usually late in appearance in the symptom-complex. I have known loss of smell to occur from a tumor at the foramen magnum, and paralysis of an external rectus muscle from a tumor of the parietal lobe. The abducens nerve has the longest intracranial course of any of the cranial nerves, arising as it does, at the union of the pons and medulla oblongata and leaving the skull through the sphenoid fissure, and one should be cautious in accepting its paralysis as a localizing sign, unless when it occurs early."

Cushing[4] attributed the abducens palsy when the tumor is remote from this nerve to constriction of the nerve by transverse branches of the basilar artery, which in many instances overlie the nerve. His studies were made chiefly on the conditions relating to this nerve, but he states that a form of vascular indentation affecting the third pair has been observed in a number of brains in his collection, and has caused a false localizing sign. He refers to a statement by Bruns regarding the possibility that paralyses may be caused, not only by direct involvement in or pressure by a growth or gumma, but also by the dislocation of the brain itself. Bruns quoted Wernicke to the effect that a basal tumor on one side can dislocate the brain in such a way as to cause paralyses by the contralateral cranial nerves, which become pressed against the sharp dural borders of their foramina of emergence, the nerves on the side of the tumor being stretched at the same time, or vessels surrounding a cranial nerve may press upon the nerve and even sever it. This has been observed in regard to the olfactorius, opticus, oculomotorius and abducens. It seems to be especially important in regard to the opticus. Oppenheim explained ipsilateral hemiparesis and hemianalgesia in a case of cerebello-pontile tumor by the finding that the vertebral artery on the opposite side to the lesion lay tightly stretched across the pons at the bottom of a deep groove, which suggested the likelihood of an interference with conduction from this cause rather than from pressure against the cranial base, or from stretching of fibres. I published in 1914[5] the photograph of a brain presenting great distortion of the cerebellum, medulla oblongata and upper cervical cord by a large cyst of the left cerebral hemisphere. Cushing does not refer specifically in his paper to paralysis of the facial nerve from remote pressure by tumor.

In Oppenheim's Lehrbuch[6] the following statements occur: "The occurrence of mistakes of diagnosis in localization in brain tumor cases, even after most exact study, is to be attributed to different factors; to remote effects (Fernwirkung), to hydrocephalus, to œdema of the brain, occasionally to chronic meningitis, to swelling of the brain, and to tissue changes caused by toxic processes. Displacement of the brain, which may be extensive, is another factor, as tumors of the cerebrum may cause displacement of the cerebellum and medulla oblongata into the foramen magnum. The pulling and displacement may affect the basal cranial nerves, especially the ipsilateral and even the opposite abducens. Exceptionally trigeminus symptoms may be produced in this manner, as Collier has shown. Tumors which are near the mid-line may press against the opposite hemisphere from that in which they arise and cause collateral focal symptoms.

This may occur also in hydrocephalus which involves especially the ventricle of the opposite side, as in the observations of Dinkler, Ziegenweidt, and Spiller."

"At one time it was believed that no attempt could be successful in localizing tumor of the brain on account of remote effects and the significance of these was overestimated. Focal symptoms may be absent a long time after a brain tumor develops."

It seems as though general symptoms in regard to cranial nerves are now more likely to be minimized and even overlooked. In many papers on brain tumor I have examined remote effects of tumor in reference to paralysis of cranial nerves are not duly emphasized. With the exception of Collier's paper I have not found specific mention of paralysis, unilateral or bilateral, of the facial nerve as a remote effect in brain tumor. It is possible, even probable, that I may have overlooked some statement in reference to this occurrence, for the literature on brain tumor is enormous.

I have recently been able to confirm a clinical diagnosis of bilateral homonymous partial right upper quadrant defect as a remote effect, I made in a case under my care. The diagnosis was tumor of the right frontal lobe and motor cortex. Doctor Frazier operated and removed a large fibroblastoma from this region. The recovery seems to be complete and the partial quadrant defect disappeared within a few weeks following the operation. The cause must have been pressure of the lower fibres of the left optic tract against the base of the skull.

E. Sachs,[7] in his book on brain tumor, says: "Perhaps the most striking single symptom of pontine involvement is complete bilateral sixth nerve paralysis. While a unilateral sixth nerve paresis is a *general sign* of intracranial pressure, bilateral involvement is an important *focal* symptom. The anatomical abnormality described by Cushing as responsible for unilateral sixth nerve paresis, may occasionally occur on both sides, but, when one considers the incidence of anatomical variations and the incidence of brain tumors, it must be apparent that this will occur very rarely." He does not consider facial nerve paralysis as the remote result of brain tumor.

Bilateral sixth nerve paralysis may be suggestive of a lesion of the pons, but I would add to this statement: provided the long sensory and motor tracts which pass through the pons give clinical signs of involvement. When these tracts escape, as shown by the case reported in this paper and in the following report, the bilateral sixth nerve paralysis is more likely to be a remote effect, although it might be produced by a small intrapontile tumor which involved both sixth nuclei which are situated close together, one on each side of the raphé. Such a small tumor would not necessarily affect the sensory or motor tracts, but it would be likely to cause also bilateral facial nerve paralysis, as this nerve winds around the sixth nucleus. Most tumors in this location would soon involve the sensory tracts of the tegmentum, and then the motor tracts. These tracts, of course, might be involved higher in the brain.

CASE REPORT.—L. D., boy ten years of age, was admitted to my service in the University Hospital February 24, 1922. Notes taken by me on his admission state that

ocular movements were normal. He wrinkled his forehead, closed the eyelids of each eye and drew up the corners of the mouth together or separately in a normal manner. He had no weakness of the upper or lower limbs. Touch and pain sensations were normal in the face. Sensations of touch, pain, position and passive movement were normal in the upper limbs. Stereognostic perception was normal in the hands. Sensations of touch, pain, position and passive movement were normal in the lower limbs.

On February 27 I recorded again that there was no weakness of the left side of the face. On February 26 Doctor deSchweinitz noted: "There is no failure in rotation of the eyeballs." On March 4 I found that the boy had some weakness of the left external rectus muscle, and on March 8 I recorded that the weakness of the left external rectus muscle was a little greater than it had been on the preceding day and that the right external rectus muscle showed a little weakness. The boy had nystagmus on looking to the extreme left and still more on looking to the extreme right. On March 8 I found that in showing the teeth there was a little less power in drawing up the left corner of the mouth. On March 9 the right external rectus muscle was as much paralyzed as the left and both were markedly affected. My diagnosis from all the symptoms, including left sided convulsive attacks and left lateral homonymous hemianopsia, was tumor of the right temporo-occipital region, and it was distinctly stated that the bilateral sixth nerve palsy of rapid development was regarded by me as suggestive of increased intracranial pressure.

Dr. Lewis Fisher on March 8 reported: "The destruction of the vestibular fibres in the right eighth nerve is definite. There is no other evidence to point to a lesion in the right cerebellar pontile angle." He also spoke of weakness of the left facial nerve.

Doctor Frazier operated on March 10 and made a right occipitoparietal lobe flap. He found the dura so tense and bulging that he did not dare to open it without lessening the intracranial pressure. A small amount of orange colored fluid was obtained from the right ventricle, and this suggested the presence of a gliomatous cyst. When the left ventricle was punctured the fluid squirted out under much pressure, confirming the diagnosis of internal hydrocephalus. The condition of the boy did not permit further examination and he did not react well. The left ventricle was tapped again March 11 and several ounces of fluid were removed from this ventricle. On March 12 his condition was very serious and he died the afternoon of that day.

Doctor Frazier's notes state that after removal of fluid from the left ventricle the convolutions of the right side were found to be yellow and flattened. Some yellow fluid was withdrawn from what appeared to be a cyst below the cortex; no tumor was found at the operation. My examination of the brain at necropsy showed a large glioma of the right temporo-occipital lobe, determined by microscopical sections. The tumor did not extend into the pons or cerebral peduncle. The right cerebral hemisphere was much enlarged. The tumor was a spongioblastoma multiforme.

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DECEREBRATE RIGIDITY IN CHILDREN

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Despite the neurological and physiological importance of Sherrington's[1] observations of the results of transection of the brain stem in experimental animals and his description of the resulting picture which he called "decerebrate rigidity" or "reflex standing," almost twenty-five years elapsed before any definite attempts were made to correlate these findings with the various aspects of spasticity as seen in man. Even though the majority of cases reported at that time by Wilson[2] have since been discredited, as presenting the exact counterpart of the experimentally produced condition, at least one must yield to him the distinction of having aroused interest in the clinical condition. In the past fifteen years not a few reports of cases simulating this experimental decerebrate rigidity have found places in the literature. As a result, there has been considerable difference of opinion as to what clinical picture constitutes its counterpart in man.

The anatomical and physiological considerations involved in decerebrate rigidity have been clearly emphasized by Walshe.[3] He considered that most of the reported cases, especially those of Wilson, are examples of different varieties of extrapyramidal syndromes or tonic fits due to a variety of extraneous causes, none of which should rightly be identified with the decerebrate rigidity of Sherrington. Walshe pointed out those criteria which he considered essential to the recognition of a case simulating the experimental condition and in a later paper reported a case which he felt fulfilled the dicta which he had laid down. His views were later reiterated by Pollock and Davis.[4]

It must be admitted that it is highly improbable that the exact anatomical lesion will ever come under observation in the clinic. However, it does seem reasonable that if, as Walshe says, "We adopt this term of precision from experimental physiology, we must be careful to use it precisely and we have no right to employ it to describe clinical conditions which differ in essential features from the experimentally produced one known by that name" (decerebrate rigidity). On the other hand, one cannot help but feel that the essentials of that lesion may be obtained; namely, interference with voluntary motor power and abolition of postural reflexes in the mid-brain.

It has been deemed necessary by Walshe, Davis,[5] Alpers[6] and Walschonok[7] to analyze this general requirement in detail and to enunciate certain physiological axioms which they feel should be considered carefully before one suggests that a given case exhibits those phenomena seen in experimental decerebrate rigidity.

Walshe has defined the quality of the rigidity as being "a true hypertonus, employing Sherrington's sense of the word tonus. It is, therefore, a proprioceptive reflex reaction, selective in its incidence in the musculature and showing reciprocal innervation. It is abolished by posterior root section. It presents the quality of plasticity described by Sherrington, though in long-standing cases of spastic paralysis fibrous contractures tend to mask this.[11] In short, there should be hypertonus which selects the extensor muscles of the extremities, and this should be accompanied by reciprocal flaccidity of the flexors. It is generally agreed, however, that in man in the case of the upper extremities spasticity in flexion is more common than in extension. The additional characteristic of plasticity may be elicited by the demonstration of yielding of the rigidity on passive stretching of the muscles, or by the production of prolonged tendon reflexes. Furthermore, it should be possible to offset the rigidity by phasic spinal reflexes.

As the result of brilliant and painstaking research, Magnus and de Kleijn[8] have described a series of postural and tonic reflexes, many of which can be elicited in the decerebrate animal and which have been demonstrated in most of the recently reported cases thought to show the phenomena of decerebration in man. However, the exhibition of these tonic reflexes is not really necessary to the presence of decerebrate rigidity. Their presence, on the other hand, adds confirmatory evidence to the supposed existence of such a syndrome.

To add another summary of all hitherto reported cases with analysis of the validity of each case seems unnecessary since Walshe, Davis, Zand,[9] and Weisenberg and Alpers have done this so adequately. However, it is interesting to note that of the twenty-one reported cases with which I am familiar ten have been children. When one considers the variety of etiological factors responsible for the degenerative, neoplastic, or traumatic lesions giving rise to the syndrome in the reported cases, one can evince no surprise that a proportionate number have occurred in childhood. Congenital aplasia, or malformation of the brain, neoplasms, Tay-Sachs disease, Little's disease, and encephalitis have been responsible for the cases occurring in childhood and since these conditions are not uncommon, it is probable that additional subjects will come under expert observation from time to time.

Since decerebrate rigidity is a condition of such clearly defined precision in experimental physiology and since each case reported in man, no matter how closely the phenomena observed may parallel those seen in animals, is subjected to such critical analysis it is with some misgiving that one ventures to claim recognition for other cases. Yet it does seem that each case which has been carefully studied adds somewhat to our knowledge of reflex activity and its localization. With these several shortcomings in mind, I offer these two cases showing phenomena ordinarily associated with decerebration and occurring in children which have come under our observation in the Pediatric Service of the Philadelphia General Hospital.

CASE I.—L. R., a girl aged seventeen months, was admitted to the service of Dr. John Holmes March 19, 1933, with the history that her birth October 16, 1931, had been normal and that she had made normal progress and shown no unusual symptoms until early in February, 1932, when she exhibited frequent attacks of vomiting which could not be explained. This condition did not improve as the result of any treatment used and in March it was noticed that her vision was impaired. In spite of these significant symptoms, she was not studied carefully and was practically untreated since it was felt that she was suffering from some hitherto unsuspected birth injury. However, her general condition did improve and her vision returned. In July, 1932, she again began to vomit and it was noticed that her head seemed to be increasing in size. It was also observed by the parents that her body was more rigid and that the legs could be flexed only with some difficulty. In January, 1933, she again began to show symptoms of greater severity. Vomiting again became noteworthy, her vision decreased, and she failed to take any notice of her surroundings. During her entire illness, she never suffered from convulsions or tonic fits. The general spasticity of her body did increase, although she never showed opisthotonos. It was reported that she had never shown any fever or disturbances of respiration. Aside from these facts her personal and family histories were unimportant.

Physical Examination.—Temperature, pulse and respiratory rates were normal and remained so for twenty-four hours after admission. The patient was a thin, white, female child of seventeen months who lay quietly in bed and who evinced no interest in her surroundings. She had no convulsive seizures and showed no cyanosis. The body lay in an extensor position and was rigid. The cranium was large, measuring forty-eight centimetres in diameter. The anterior fontanelle was wide, measuring three by four centimetres, and the cranial sutures spread open. The facial expression was rather wooden and the eyes were turned to the right. The pupils were equal and reacted slowly to light. No winking or nystagmus could be observed. The fundi showed secondary optic atrophy but there was no unusual color noted in the macula. The neck was somewhat stiff, but the head could be moved from side to side. The upper extremities were held flexed and pronated, the lower extremities extended with the feet dorsally flexed. When the lower extremities were irritated, there was increased tonus of the extension. All extremities showed a spastic or claspknife type of rigidity. The abdominal reflexes were absent but the biceps, triceps, patellar and Achilles reflexes were hyperactive. The patellar reflexes exhibited the step-ladder phenomenon of spasticity. Dr. A. Ornsteen, called in consultation, confirmed these findings and demonstrated also the presence of the tonic neck reflexes of Magnus and de Kleijn. The Babinski sign could not be elicited. Sensation could not be tested accurately.

A lumbar puncture done March 20 revealed clear fluid under greatly increased pressure. Shortly after this, the child's condition changed for the worse. Her temperature began to rise and she had occasional attacks of cyanosis. At intervals, she showed tremors of a coarse rhythmical type and rotatory nystagmus. March 21, her temperature had risen to 105° F. and her condition was so critical that further studies were impossible. A cisternal puncture revealed clear fluid under pressure equal to ten millimetres of mercury. Chemical analysis of the fluid gave normal findings and no bacteria were found. Death occurred soon after this.

Autopsy Findings.—Examination of all organs except the brain proved essentially unimportant. The description of the brain and the histological description of the tumor by Dr. Helena Riggs are reproduced herewith. "The specimen (Figs. 1 and 2) is large for an infant and shows evidence of marked obstructive internal hydrocephalus. There is an enormous tumor of the orbital surface of the hemispheres. This is lobular and cystic in some portions. It measures nine by seven centimetres. It has compressed the orbital surfaces of the frontal lobes and the mesial surfaces of the temporal lobes and lies in the depression thus formed. It extends anteroposteriorly from the frontal poles to the level of the fifth nerve at the basis pontis. It lies over and obliterates the struc-

FIG. 1.—Orbital surface of brain in Case I. Shows size and relation of tumor mass to cerebrum and mid-brain.

FIG. 2.—Section through brain to show relation of tumor to the ventricles which are dilated.

tures of the interpeduncular space. The flattened olfactory bulbs can be seen beneath it, and the third nerve courses over it. Many dilated surface vessels are noted over the tumor. The tumor lies below the subarachnoid space, and the dilated basal cistern filled with fluid is noted over the tumor mass. Longitudinal section of the brain shows a circumscribed, fleshy tumor in the mid-line which obliterates all basal ganglia. The anterior and posterior horns of the lateral ventricles are enormously dilated but the bodies of these ventricles are obliterated."

Histological examination showed "an extremely vascular mass with a fibrocellular structure between. (Figs. 3 and 4.) It is not well defined though grossly it did have that appearance, but areas are visible where the newly formed tissue is invading comparatively normal brain tissue. For the most part the vessels have thick and well-formed walls with swollen endothelial cells. Some of the vessels, however, have extremely thin and poorly developed walls. The cellular structure of the tumor is rather loose with a great deal of loose connecting substance between, some of which is fibrous tissue. While a great deal of the tumor was softened, there are no areas of degenera-

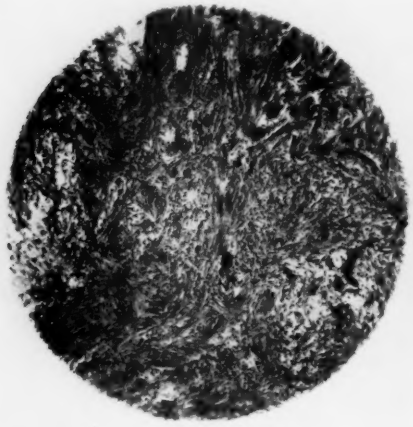

FIG. 3.—Shows typical stroma of the tumor. H. and E. stain x 57.

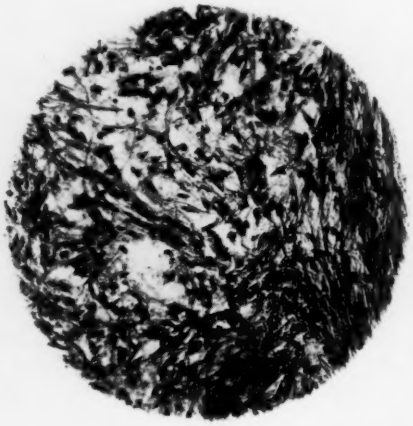

FIG. 4.—Showing cellular and fibrous matrix of tumor. H. and E. stain x 207.

tion visible in the sections examined. The nuclei making up the bulk of the tumor are oval or carrot-shaped with protoplasmic processes extending from both poles. There is no uniform arrangement of the cells, but one does see them placed here and there in the form of sheaths. Mitotic figures are not seen."

There has been no general agreement as to the exact diagnosis of this tumor, but it is felt that it is a glioma, possibly falling into the spongioblastoma or Schwannoma groups.

CASE II.—M. M., aged twelve months; admitted first to Philadelphia General Hospital, July 29, 1929, with the history that she had had a cough for three or four days of a spasmodic type, worse at night. The day before admission, she had had slight fever but none was recorded on admission. Although she was not seriously ill, she was admitted mainly because home conditions were such that adequate care was impossible. Her previous record was to the effect that she was born at term and weighed about seven pounds. She was nursed for four months and then fed on an adequate formula. Her development was normal up to the time of admission. Her mother was in good health, but just prior to her illness her father was admitted to another hospital with the diagnosis of encephalitis. Two older children were in good health.

Physical examination at the time of this first admission showed a well-developed, well-nourished female child of one year who was able to walk about her crib and who

evinced intense interest in her new surroundings and who offered reasonable coöperation to her examiner. The only findings of note at that time were a paroxysmal cough, slight fever, moderate rhinopharyngitis and otitis media. The lungs seemed clear except for inspiratory stridor but no râles were heard. By the fourth day after admission, the character of the cough had changed sufficiently so that a diagnosis of pertussis was obvious. This diagnosis was supported by the characteristic blood-picture of absolute and relative lymphocytosis. She was, therefore, transferred to the Hospital for Contagious Diseases.

A few days after admission to the Contagious Hospital, her condition became much worse. She had high fever, dyspnœa and cyanosis. At that time, she was thought to have a complicating bronchopneumonia. August 11, 1929, the child had a convulsion, more marked on the left side of the body. Following this convulsion, she never regained control of her extremities and remained in a semistuporous condition. A lumbar puncture done at that time revealed clear fluid under increased pressure. There was a pleocytosis of fourteen lymphocytes, but examination of the sugar, albumen and bacterial content of the fluid showed no pathological changes. A few days later, it was noticed that the child showed spasticity of all extremities. When her fever had subsided and her general condition had improved so that she could be moved, she was returned to the Philadelphia General Hospital September 16, 1929.

Examination of the child upon the date of readmission to the Philadelphia General Hospital showed an emaciated, dehydrated female child of fifteen months who lay motionless in the bed and who seemed to be suffering from no pain or discomfort. She was not stuporous, but her attention could not be attracted by most external stimuli and she made no voluntary movements. She could be fed only liquid food. Her posture was that of extension with spasticity of all extremities, but there was no stiffness of the neck. The biceps, triceps, patellar and Achilles jerks were reported as being somewhat hyperactive, but no clonus was observed. She showed a positive Babinski reflex. She reacted to sensory stimuli with slight exaggeration of the extensor posture. The pupils were equal and reacted to light and there was no nystagmus. The eyegrounds were not examined. No other findings of neurological importance were recorded at that time.

In March, 1931, she was carefully studied by Dr. A. Ornsteen. Notes recorded at that time showed that she lay in the bed practically motionless with the body in the extensor attitude. The arms were acutely flexed and pronated and the fingers flexed. The rigidity of all the limbs proved to be of the plastic type. The lower limbs were in extreme extension with adduction; the feet were in a *pes cavus* position. The knee-jerks were brisk and showed the "step-ladder" phenomenon. No other deep reflexes could be obtained and the Babinski, Gordon and Oppenheim reflexes were negative. Sensory stimuli brought ipsolateral and contralateral response, increase of extension in the lower limbs and decrease of the flexed position of the arms.

Loud noises close to her ears brought a blinking response as did similar stimuli near the eyes. No nystagmus was noted. The eyegrounds showed optic atrophy with pigmentation. No tonic spasms or convulsions were noticed. She did not at that time show the neck reflexes of Magnus and de Kleijn. Doctor Ornsteen considered the attack of pertussis to be of etiological significance but felt that the diagnosis could not be made with certainty. He suggested Schilder's encephalitis, the Bielschowsky type of Tay-Sachs disease or encephalomyelitis disseminata. He did feel that she presented a syndrome similar to that seen in decerebrate animals.

This child came under my care in October, 1932, at which time her neurological condition was essentially the same as that recorded above. She did, however, show typical tonic neck reflexes of Magnus and de Kleijn. Since September, 1929, this child has continued to lead a vegetative existence in our ward. She can be moved and changed only *en bloc* due to her rigidity. She is so helpless that liquids are offered by nursing bottle and solid foods can be given to her only with great difficulty. She

has never made any conscious movements and has never exhibited convulsive seizures of any type. At times when apparently hungry or when suffering external irritation, she cries with a whining cry unaccompanied by tears. She is incontinent of urine and fæces. Despite her helplessness, she has never had any pressure necroses. Some months ago, a pathological fracture of one femur developed. Röntgenograms of the leg and other bones showed moderate atrophy, and it is believed that the fracture was due to injudicious attempts to flex the leg in the presence of disuse atrophy of the bones. Appropriate surgical treatment of the fracture, together with the use of viosterol, twelve drops daily, caused union of the fracture with sound callus formation.

Examination of the temperature charts over a period of four years with knowledge of existing conditions in our ward shows that she has slight loss of temperature control. She is apt to show an elevation of body temperature of 2° or 3° on summer days when the temperature is above 95° and slightly subnormal temperatures in the winter. Careful attention to fluid intake and protective coverings is necessary to keep her body temperature at the average normal.

As so frequently happens in spastic paralysis of long duration, tendon contractures eventually cause fixation of the limbs so that few of the phenomena can be elicited. In the past six months, this has happened to our case. Perhaps there has been increase or variation in the cranial pathology, but it is felt that the abnormal position necessary in the treatment of the fracture of the femur had considerable to do with the alteration in her general position. The position of the upper extremities is just as previously described, except that contractures prevent free responses to the neck reflexes. One leg is now fixed in a slightly flexed position and the other is flexed to mid-position on the thigh. Both are held quite firmly by fibrous contractures of the tendons. It can be noted, however, that the extensor muscles are still tonic whereas the flexors are flaccid. The position is maintained by tendon contracture solely. This position makes the elicitation of phenomena once obtained with ease well-nigh impossible. Aside from this, her general condition remains about the same.

In October, 1931, a röntgenological examination of her skull showed practically a normal appearance with no evidence of intracranial pressure. In early January, 1933, another film pointed to slight enlargement of the cranium, distortion of the middle fossa downward and forward and of the sella turcica anteriorly, although other confirmatory signs of internal hydrocephalus were lacking. It is difficult to correlate these findings with the diagnosis we have postulated but we do not feel that a neoplasm is present, although that is suggested by the röntgenogram.

Comment.—Although the lesion was of much greater size for such a small patient, Case I here presented resembles somewhat the lesions and the symptoms observed in those cases reported by Walshe and by Davis.[10] There can be little doubt that this tumor was capable of producing such marked compression on the structures in the anterior part of the brain stem as to give rise to physiological decerebration somewhat analogous to that seen following a lesion experimentally produced in an animal in this same region. The rapid demise of the patient following her admission to the hospital was at first puzzling. Bazett has called attention to the fact that such a disaster is apt to happen in animals if an uncontrolled hæmorrhage spreads down over the lower brain stem. No such hæmorrhage was found at autopsy. It is, therefore, suggested that a lumbar puncture followed by the removal of too large a quantity of fluid resulted in such an alteration of internal pressure relations that a spreading œdema simulated the condition described

by Bazett.[11] Perhaps the change in fluid pressure in the ventricular and subarachnoid systems permitted swelling of the tumor itself due to vascular engorgement. If so, it will be simpler to explain the pre-lethal rise in temperature on the basis of the recent work of Bazett, Alpers and Erb,[12] who studied the relation of the hypothalamus to temperature control, using varying levels of decerebration to produce preparations for their studies.

In this case and in the second also, it will be noted that the upper extremities were held in a flexed position. Attention has been drawn to this previously by other observers. Some authors explain this variation from the picture seen in animals on the grounds of evolutionary changes in the use of the upper extremities by man. It is not beyond the range of possibility that it is due to variation in the position of pyramidal tract fibres controlling the action of the muscle groups in man as compared to animals ordinarily used in decerebration experiments.

The second case is interesting, both from the standpoint of symptomatology and etiology. One cannot help but feel that the acute manifestations which occurred during the attack of pertussis were due to acute encephalitis and that the chronic state which resulted is due to degeneration of those portions of the brain stem which are concerned with the production of physiological decerebration. One cannot, however, dismiss the suggestions offered by Doctor Ornsteen, nor can one entirely rule out neoplasm, especially in view of the more recent röntgenological report. In the event of the demise of this unfortunate child, we shall report later concerning the pathological findings and shall attempt to correlate them with the phenomena which have been described here.

SUMMARY

(1) The anatomical and neurophysiological considerations involved in producing phenomena in man similar to those seen in decerebrate animals have been emphasized again.

(2) In spite of the restrictions which one should bear in mind when one uses such a term of precision as decerebrate rigidity, we have ventured to outline the symptoms shown by two children. The syndrome in each one is suggestive of the picture seen in decerebration.

(3) The etiological factor in one case was an intracranial tumor of unusual size. The etiological factor in the other case is as yet unknown, but is postulated as being encephalitis following pertussis.

The author wishes to thank Doctors Le Boutillier and Holmes for permission to report these cases.

NOTE.—Since submitting this paper for publication the child described as Case II died. Necropsy revealed that there was an extensive encephalitis involving mainly the basal nuclei. Complete sections are not available for inclusion in this paper.

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BENIGN CYSTS OF THE CEREBELLUM

WITH A REPORT OF TWO CASES

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True benign cysts of the cerebellum have been observed so rarely that the two cases herewith reported will be of interest. Each patient was subjected to a careful clinical examination and the pathological material to painstaking microscopical study. Many of the cases reported in medical literature are not true benign cysts. The diagnosis was based only on the microscopical examination of a specimen removed at operation or perhaps after an incomplete pathological examination of the cyst wall at the necropsy. The two cases recorded emphasize the necessity of a careful and minute microscopical examination of sections from every part of the cyst wall in order to exclude any evidence of a tumor, before classifying them as so-called simple or benign cysts. The nature of these cysts, the clinical differential diagnosis, the complications and the treatment are discussed.

Many cases have been recorded as simple or serous cysts including those of Sharkey, Hadden, Habersohn, Gowers, Bastian, R. Williamson,[1, 2] Martin, *etc.* They are uncommon lesions and consequently detailed histological descriptions of them are rare. Many of them were examined only during the operation. In both cases reported by Williamson as serous cysts, further microscopical examination disclosed a small area of new growth (gliomas in the cyst wall). Careful microscopical study of these cysts has been made by Virchow, Bruns, Herzog, Schule, Lichtheim[3] (1905), F. Henschen,[4] (1907), Wersiloff (1913), Bielschowsky (1920), N. Antoni[5] (1926), Arwid Lindau[6] (1926), *etc.*, and their nature has been discussed. All of the reported cases were clinically unrecognized and were either accidental operative or unexpected post-mortem findings.

CASE REPORTS

Case I. *Summary.*—Surgical Index File No. 21838. Progressive signs of increased intracranial pressure of two years' duration. Recent signs of cerebellar involvement. Ventriculography followed by signs of medullary compression. Emergency operation revealed a large cerebellar cyst which was evacuated and a portion of the wall removed. Improvement after operation. Patient died thirty days post-operative from bronchopneumonia. Autopsy: Cerebellar cyst; non-communicating type of hydrocephalus. Advanced bronchopneumonia and lung abscesses of both lower lobes. Multiple duodenal peptic ulcers.

T. H., male, thirty-seven years old, was referred to the Neuro-Surgical Service of the University of Pennsylvania Hospital by Dr. R. F. Leinbach, Charlotte, N. C., May 26, 1931. *Chief Complaints on Admission.*—Headaches, nausea, vomiting, diminution in vision, diplopia, staggering and difficulty in talking.

History of Present Illness.—Patient was perfectly well until two years ago when he

began to complain of headaches, starting at the vertex, and extending down over the left side of the face, becoming progressively worse and involving the entire head. Two months ago, he suffered attacks of nausea, vomiting, blindness, and uncertainty in gait with a tendency to deviate to the left and backward. Since that time he has remained in bed. Two weeks ago he entered the Presbyterian Hospital in Charlotte, N. C., for observation and treatment. During this period he experienced a sensation of weakness in his left arm and left leg, a tingling sensation in his left hand, tinnitus and pain in the ears, and great difficulty in talking, his tongue feeling stiff and his palate cold.

Personal History.—As a child he fell and struck the left side of his head. Measles, pertussis, rheumatism. No history of alcoholism.

Family History.—Mother died from a stomach lesion.

Physical Examination.—A white, adult male, well nourished, well developed, resting in bed. Patient is not paralyzed, and does not give an appearance of having been ill. Temperature 98.2°. Pulse 88. Respiration 20. Blood-pressure 118/85. Heart and lungs negative. Abdomen negative on palpation. Examination of all other organs does not reveal any clinical pathology.

Neurological Examination.—Conscious, oriented in time and place, alert and coöperative. Has a good memory. No disturbance of speech. Head examination is grossly negative except for tenderness on palpation and percussion in the region of left mastoid area.

Subjective Complaints.—Pain involving entire head; nausea, vomiting, weakness of his left extremities, tingling sensation in the left forearm, numbness of the left side of the face and left half of the tongue. Staggering.

Cranial Nerves.—Diminution in visual acuity. Visual field; peripheral constriction, enlarged blind spots. Fundi; retinal arteries contracted, veins engorged, few retinal, hæmorrhages. Disks fuzzy, gray in color. Choked disk. O.D. and O.S. plus 3 D. Diplopia in looking to the left. Anæsthesia over all three divisions of the fifth nerve, subjective numbness. No deviation of the lower jaw.

Sensibility.—Subjective; tingling sensation in the left forearm. Tinnitus, buzzing in the left ear. No disturbance of objective sensibility over the body. No astereognosis.

Motor System.—No involuntary movements. Voluntary movements are normal. Patient does not present any paralysis or atrophy.

Deep Reflexes.—Hyporeflexia.

Superficial Reflexes.—Normal except for the left corneal reflex which is lost.

Coördination, Gait, Equilibrium.—Station insecure, falls backward. His gait is unsteady, he falls off the line to either side and cannot walk on straight line with heel and toe; asynergia; vertigo; no nystagmus; no abnormal posture of the head.

X-ray.—Questionable erosion of the petrous ridge on left side. This might be due to an angle tumor in this locality. Pineal calcification shows no mid-line shift. Pituitary fossa is normal in appearance: A.P. 8 millimetres; depth 7 millimetres. Heart and lungs appear normal. Neck negative. Swallowing function with an opaque mixture is normal.

Vestibular Reactions.—Marked disproportion between the duration of nystagmus and vertigo after turning to the left. There is a considerable loss of function of the right vertical semicircular canals. The right horizontal semicircular canal responds fairly well. Some loss of function of the left vertical semicircular canals, but to a lesser degree than on the right. The left horizontal semicircular canal responds well except that the nystagmus obtained after stimulation is inverted. The hearing is fairly good in both ears. These findings are strongly suggestive of an intracranial lesion. The lesion is probably supratentorial and in the mid-line.

Ventriculogram.—The localization being uncertain, an air injection was made under local anæsthesia (June 12, 1931). The X-ray films showed marked dilatation of the lateral ventricles, which were symmetrical in shape and showed no mid-line shift. The upper portion of the aqueduct of Sylvius contained a little air. The lateral view of the

head with patient's face downward also showed slight filling of the aqueduct and the fourth ventricle. Ventriculogram diagnosis: posterior fossa mid-line tumor.

Operation.—June 12, 1931. The patient showed signs of medullary compression and a suboccipital craniectomy was performed. A cerebellar cyst found, evacuated and a portion of the wall removed. Operative notes. This patient had a ventriculogram made in the morning and vomited incessantly, fainted on the table and it seemed wise to postpone the exploratory operation until he had had time to react, especially as we had taken precautions to remove all air from the ventricles immediately after the ventriculogram was made. However, about six o'clock on the evening of the ventriculogram, he began to show signs of medullary compression, and about 8 P.M., under local anæsthesia, we proceeded hastily with a suboccipital craniectomy. During the early part of the operation, the patient had periods of apnœa but the color of the blood, for the most part, was bright red.

We observed that the bone in the occipital region was abnormally thin. As soon as the dura was punctured, and in ligating the occipital sinus, a considerable quantity of fluid escaped from the posterior fossa. The posterior rim of the foramen magnum was removed as was the first lamina and part of the second. When the occiptal sinus was ligated the dural incisions extended from side to side and downward as far as the second lamina, we had an adequate exposure of the hemispheres and the relation of the tonsils to the foramen magnum. They had evidently been forced down by the previously existing pressure.

Further inspection revealed an enormous collection of fluid, the color of which was not recorded, but the collection seemed to be encapsulated; the sac was of a muddy green color. The left cerebellar hemisphere was not more than a third as large as the normal hemisphere. The cyst had extended across to the opposite side more or less undermining the right hemisphere. A portion of the cyst wall was removed and sent to the laboratory for examination. As soon as the brain stem was adequately decompressed by removal of the upper laminæ and by the free incisions of the dura, the respiratory rate and function became quite normal and from that time on we had little or no concern about the patient. In wound closure we were particularly careful that our hæmostasis was complete and when finished the field was satisfactorily dry.

Post-operative Course.—Following the operation the patient's condition improved. Seven days later (June 19, 1931) he developed bronchopneumonia to which he succumbed. The pneumonia was not thought to be sufficient to account for the high sustained temperature, pulse and respiration, but no other cause of death could be found. Repeated blood transfusions were given which sustained life fairly well, for several weeks, but the patient slowly grew weaker and on July 13, 1931, he suddenly collapsed.

Comment.—Bronchopneumonia is not an uncommon complication after cerebellar operations, but we held ourselves more or less accountable in this, however, because we departed from our usual practise and did not operate on the morning of the day on which he had the ventriculogram. We had to operate under some difficulties when, in the afternoon, he developed a cerebellar crisis. The shock to the patient was of course greater in operating under this emergency than had we been able to proceed more deliberately in the morning.

PATHOLOGICAL REPORT.—*Brain.*—On removing the calvarium, both an extradural and a subdural clot is disclosed. These are located in the right occipital region at the site of the ventricular puncture and have caused compression of the cortex in this area. There is some congestion and œdema of the brain. The collapsed cyst of the cerebellum is seen and the operative site in the left suboccipital region exposed. The dura is open at this point. Two trephine areas are seen from a recent ventriculography.

The cerebrum shows evidence of a moderate degree of œdema. There is likewise some pia-arachnoid thickening. The cerebellum is the seat of a large cyst which occupies the vermis and extends laterally into the adjacent hemisphere. It is collapsed. Its wall

is formed by thinned-out and compressed cerebellar tissue and by a thin fibrous membrane. The cyst occupies practically the entire inferior vermis in its posterior portion. Section of the brain shows a moderate degree of hydrocephalus, involving the lateral, third and fourth ventricles.

Pathological Diagnosis.—Cerebellar cyst, non-communicating type of hydrocephalus.

Microscopical Description.—The tissue is composed of a delicately fibrous cyst wall and of small areas of hæmorrhage here and there. No tumor is found. Additional sections were examined in the laboratory of surgical pathology at the University of Chicago. These showed the wall of the cyst to be composed of connective tissue and to be infiltrated with lymphocytes, plasma cells, polymorphocytes, leucocytes and mononuclear cells, many containing hæmatii. This examination confirmed the report by Dr. Alpers in the Neuro-Pathological Laboratory in this Hospital in that there was no evidence of tumor tissue. The surrounding cerebellar tissue is atrophied.

Spinal Cord.—The dura showed no thickening. On palpation the dura and cord beneath felt fairly firm throughout. After section the dura and cord appeared to be uniform in thickness, and to be loosely applied around the cord. The arachnoid was normal in appearance. The cross-sections of the cord appeared normal throughout its length.

Heart.—Slight hypertrophy. *Thyroid.*—Negative. *Lungs.*—Advanced bronchopneumonia and lung abscesses of both lower lobes. The microscopical picture is that of a severe bronchopneumonia in which many areas have broken down and formed abscesses. Thromboses and infarcts appear in other areas. *Liver.*—Cloudy swelling. *Spleen.*—Acute splenitis with passive congestion. *Adrenals.*—Negative. *Kidney.*—Slightly cloudy swelling with passive congestion. *Bladder and Prostate.*—Negative.

Gastro-intestinal Tract.—On opening the duodenum, several peptic ulcers are found. Immediately distal to the pylorus are two ulcers about one centimetre in diameter. The margins are not inflamed. There is a small stellate ulcer distal to these. The surrounding mucosa has a rather congested, hyperæmic appearance. About two centimetres beyond the pylorus a very large oval ulcer is seen, measuring 4 centimetres by 5 centimetres. It has completely eroded the intestinal wall so that the head of the pancreas forms its base. The margin of the ulcer is not thick and indurated, nor is it congested. The remainder of the digestive tract was searched for ascaris parasites but none were seen. The section from the margin of the large duodenal ulcer shows the mucosa to end abruptly at the margin of the ulcer; the muscularis also has disappeared. A portion of pancreatic tissue forms a part of the floor of the ulcer. The superficial cells, *i.e.*, those toward the lumen of the duodenum, show considerable distention with nearly complete destruction of the acini, only the reticulum remaining. The basic cells are well preserved.

Pancreas.—The pancreatic acini, for the most part, are well preserved. In some areas the cells show atrophic changes and an increased amount of intralobular fibrosis. The islets are of normal size and number. Another section of the pancreas shows the intralobular fibrosis more extensively. Here many acini are markedly degenerated, only fragments of the cells remaining and the whole area undergoing fibrotic changes.

CASE II. *Summary.*—A male subject in his thirty-eighth year exhibited progressive signs of a brain lesion of five months' duration. Unlocalizable without air injection. The patient died the day following admission of medullary compression. No operation. Necropsy discloses cerebellar cyst. Non-communicating type of hydrocephalus. Œdema of the brain. Definite foraminal cone.

M. E. S. (File No. 21982), aged thirty-eight years, was referred to the University Hospital by Dr. J. H. Vastine of Shamokin, Pa., May 8, 1931. The patient was admitted first to the Neurological Service of Dr. W. G. Spiller and immediately transferred to the Neuro-Surgical Service.

Chief Complaints.—Headaches, vertigo, vomiting, weakness of both legs, convulsions.

History of Present Illness.—July, 1923, the patient fell on his back sustaining two

contusions in the lumbar region. He remained in bed for seven months complaining of numbness in his left lower extremity. In December, 1930, he first complained of nausea and vomiting. April, 1931, he had an attack of vertigo, fell, striking his head in the occipital region. Following this attack, he developed headaches, which became progressively worse, and clonic convulsions of his upper extremities.

Family History.—Negative.

Physical Examination.—Revealed a rather undernourished, emaciated adult with atrophy of the lower extremities. Poor oral hygiene. Temperature 97°, respiration 14, pulse 102. Heart and lungs negative. Abdominal organs negative.

Neurological Examination.—Conscious, oriented as to time and place, coöperative, poor memory. No disturbance of speech. His subjective complaints were severe headaches of throbbing type and sharp lightning pain in the vertex; vertigo, vomiting and weakness of both legs.

Cranial Nerves.—Visual field, slight peripheral contraction and enlarged blind spots. Papillœdema O.S. and O.D. plus 2 D. The right pupil is larger than the left. No nystagmus. There was a fairly coarse tremor of the tongue.

Sensibility.—No disturbance of objective sensation, no astereognosis.

Motor System.—Attacks of clonic convulsions of arms and shoulders. Atrophy of muscles of the extremities.

Reflexes.—Hyporeflexia of the upper extremities. Bilateral Babinski.

Coördination, Gait, Equilibrium.—Station and gait cannot be tested because of weakness of the extremities. Slight dysmetria and asynergia of the lower extremities, particularly the right.

Course of the Disease.—At 7 P.M. on the day of his admission to the Neuro-Surgical Service he developed an attack of apnœa. A ventricular tap was performed and 20 cubic centimetres of fluid removed from each ventricle under moderate pressure. Seventy cubic centimetres of a 50 per cent. solution of glucose was injected intravenously. This was effective in meeting the emergency. The patient became completely conscious and was able to converse intelligently. However at 1 A.M., the following morning, the patient developed a second attack of apnœa from which he did not recover. An autopsy was performed and a definite foraminal cone was found.

Neuropathological Report.—(Dr. B. J. Alpers.) Description of the gross specimen.—The brain weighed 1,530 grams as it lay *in situ* with the calvarium removed; there was no undue tension noted on palpation of the cerebral hemispheres. The dura lay over the cerebrum in a rather lax sheet. It was under no noticeable tension. The pons seemed markedly swollen. The brain was markedly œdematous everywhere but the membranes and vessels were normal. The basilar vessels were pulled so tightly over the swollen pons that they had cut a deep groove in this structure. Section of the brain revealed a pronounced hydrocephalus, involving all the horns of the lateral ventricles, and dilatation of the third and fourth ventricles. Otherwise, the cerebrum showed nothing of importance.

The right cerebellar hemisphere on gross inspection showed a definite softening on its superior aspect and was likewise collapsed. The labus quadrangularis was softened practically throughout its entire extent. At the posterior end of the softened area was a small patch of calcification which appeared to be in the pia. Section of the cerebellum showed a cyst with a well-definied wall, involving the right labus quadrangularis, and extending over the part of the inferior vermis. Posteriorly it involved the superior vermis and pushed this structure over to the left. The right dentate nucleus was compressed by the cyst. The cerebellar cortex was atrophic and had lost its normal architecture on the upper surface of the cyst. The nature of the fluid contained in the cyst was not noted.

Pathological Diagnosis.—Cerebellar cyst. Non-communicating type of hydrocephalus.

Microscopical Examination.—There is a well-defined cyst in the substance of the

cerebellum. Around the cyst the white matter is rather increased in amount. Around the cyst cavity there is a great abundance of firm, hard fibrillæ which run in many different directions. These are most numerous immediately adjacent to the cyst cavity and become less dense as one leaves its vicinity. Often they are arranged in dense parallel bands following the course of this cyst. The cyst wall, or rather the portion of the cerebellum adjacent to the cystic cavity, is relatively acellular. There are very few cells. Those present contain oval, vesicular nuclei and vaguely resemble astrocytes. There are quite a few blood-vessels around the cyst cavity and many of these are filled with blood.

No true tumor tissue could be found in the cyst wall. Nor was any nubbin found in the gross specimen. The lesion can be defined only as a cerebellar cyst. Its true nature is undetermined. The lesion appears much like a syringomyelic cavity.

Additional sections were examined microscopically in the laboratory of surgical pathology at the University of Chicago. The wall of the cyst was formed of adult glial tissue. No embryonal cells suggesting a tumor were detected in the cyst wall. The examination suggested a simple gliotic cyst and the structure of the wall is very like that of the wall of a syringomyelic cavity. There are seen numerous thickened fibres which are identical with those ordinarily called Rosenthal fibres in syringomyelia. Also numerous cells are present resembling Russell bodies. No compound granular corpuscles are seen and no inflammatory cells. No signs of old hæmorrhage are to be found.

DISCUSSION

Frequency of Cerebellar Cysts.—The cerebellum is a favorite seat for tumors, especially in childhood. The statistics of Allen Starr show a proportion of nine cysts to 128 tumors, a 6.5 per cent. ratio. Martin found that of ninety-five gliomatous cysts in Cushing's series 55 per cent. were located in the cerebellum. The operative records of Frazier[7] (1905) gave a proportion of 8.4 per cent. and of Grainger Stewart 13.6 per cent. In general, cysts are found in about 10 per cent. of all cerebellar tumors. In his entire series of verified brain tumors, Cushing had observed only six benign cysts, two of undetermined nature, two echinococcal and two of the choroid plexus. In the brain tumor series of Frazier there were only two benign cysts, above reported. Dr. Walter E. Dandy and Dr. Percival Bailey reported verbally to the author that they had never encountered simple non-neoplastic cysts.

Symptomatology.—The chronology in the two cases herewith reported was similar. In each the first symptoms were those of increased intracranial pressure; signs of cerebellar involvement followed. There was a history of trauma in both cases, in Case II followed by progressive and severe symptoms of brain involvement. The duration of symptoms was two years in the first and five months in the second. Headaches were severe in both cases with sharp lightning pain mainly in the vertex but involving the entire head. Nausea and vomiting were pronounced. Impaired vision was associated with bilateral papillœdema, of 2 to 4 D. In both cases there were vertigo and dizziness, incoördination of movement in the extremities, instability of station and gait, associated with hypotonicity, hyporeflexia and asthenia. There was no nystagmus, no abnormal posture of the head or stiffness of the neck, no mental changes. Convulsions and pyramidal signs were present in the second case.

The symptoms can be accounted for by (1) obstructive hydrocephalus,

(2) destruction of the cerebellum, and (3) by pressure on the neighborhood structures (cord, medulla oblongata, pons, *etc.*). The röntgenogram revealed signs of convolutional pressure, atrophy of the calvarium and erosion of the sella turcica (due to pulsation of the distended floor of the third ventricle). In both cases there were symptoms of medullary compression due to cerebellar herniation. In Case I these symptoms followed the ventriculogram and in Case II they developed spontaneously.

Classification.—I. *Intracerebellar cysts,* associated with tumors. (1) In cysts with tumor growth in their walls, the mural tumor may be extremely small and may easily escape detection if the examination is not carefully done. Sometimes it is microscopical in size so as to require serial sections of cyst wall for identification. It may be a glioma, a hæmangioblastoma, or in rare instances, a metastatic tumor (carcinoma, sarcoma). Cushing[8] and Bailey[9] found in their series of ninety-five cerebellar cysts (to February 1, 1928) twenty-eight cases identified only by xanthochromic fluid, and sixty-seven were verified by the discovery of a mural nodule. Of the sixty-seven, forty-nine were astrocytomata, four hæmangiomata, two spongioblastomata, two medulloblastomata, one pineoblastoma and nine unclassifiable. (2) Dermoid and cholesteatomous cysts formed by lamellæ of polygonal cells which contain fat and cholesterin crystals. (3) Parasitic cysts. Cysticercus cellulosæ and echinococcus. In both cases the parasite may be identified and the membranes are easily recognized. (4) Simple cysts without the slightest trace of a new growth in their wall as determined by a scrupulous microscopical examination. The cyst wall is formed by a gliotic tissue resembling that of a syringomyelic cavity. (5) Cysts following hæmorrhage or softening. These are very rare. Scholz (1906) and F. Henschen (1907) quoted eight such cases published fifty years ago. Both groups 4 and 5 alone are properly designated as benign cysts.

II. *Extracerebellar Cysts.* (1) Meningitis cystica, may be either a generalized process or a cystic localized arachnoiditis. Histologically there is an inflammatory thickening of the arachnoid membrane forming the cerebellar and basal cisterns, sometimes associated with a concomitant encephalitis. The majority of the cases reported have been indistinguishable clinically from tumors of the cerebellum. Among the cases recorded are those of Quincke (1893); Schlessinger (1898); Spiller, Musser and Martin (1903); Mendel and Adler (1908); Nonne, Horsley (1909); Oppenheim and Borchardt (1910); P. Bailey,[10] (1920); Frazier[11] (1930). (2) Ventriculocele of the fourth ventricle. Papillomata as described by Virchow (1863), Recklinghausen (1864), Annuske (1873), Sutton (1886), Bielschowsky (1902), Karlefors (1924) are considered as abnormalities of the lateral recesses of the fourth ventricle. Microscopically they are formed by papillæ covered by typical cuboidal cells, upon a connective-tissue base, as in the normal plexus. (3) Cystic formation associated with acoustic tumors and large craniopharyngeal pouch tumors. The latter may extend from the pituitary region alongside the brain stem causing cerebellar symptoms.

Pathological Consideration.—Cystic degeneration of gliomata, much less frequently fibroblastic meningioma and carcinoma, is common in comparison with the simple or benign cysts. A cerebellar cyst should only be classed as a benign cyst, when a careful and minute microscopical examination has failed to reveal any evidence of tumor growth, in its wall, and where there is no evidence of syringomyelia. The two benign cysts above described are mesially and symmetrically situated, expanding laterally and displacing the adjacent hemispheres with no definite communication with the fourth ventricle but bulging into it.

In the first case the wall was formed by connective tissue with evidence of old hæmorrhage and inflammation. No embryonal cells, such as would suggest a tumor, were visible. In the second case, the wall was formed by a gliosis composed of irregular fibrillæ as described by Rosenthal, in dense, perpendicular and variable bands, more numerous immediately adjacent to the cyst cavity. There were a few cells with oval vesicular nuclei resembling astrocytic cells. Some blood-vessels around the cyst cavity were seen. The lesion was composed of adult elements, on the internal surface of the cyst wall. There were visible neither tumoral proliferation, embryonal cells nor ependymal cells. In neither case were there signs of an old hæmorrhage, and around the cyst walls the cerebellar cortex appeared atrophic and had lost its normal architecture. In both there was an associated secondary obstructive hydrocephalus due to obstruction of the fourth ventricle.

Etiology and Pathogenesis.—In both cases there was a history of cranial trauma. In spite of the fact that there have been described in literature cystic formations following hæmorrhage or secondary softening in the brain substance, the origin of traumatic cysts is not yet clearly explained. Hæmorrhages are very rarely seen in the cerebellum or hemisphere and in the reported case trauma was not followed by any definite brain stem or cerebellar symptoms. It is also questionable if, after resorption of the hæmorrhage, the cyst is likely to increase in size or the cavity to have a well-marked wall. The hæmorrhage due to trauma may be regarded as a coincidence in a preexisting cyst and the onset of symptoms may be attributed to the occlusion by trauma of the communication between the cyst and the fourth ventricle or subarachnoid space.

It is unlikely that these cysts are the result of a retrograde metamorphosis of the tissues following trauma, associated with hæmorrhage or interference with the blood supply. Were these cysts of traumatic origin the color of the cyst wall would be that of preëxisting hæmorrhage and the microscopical examination would reveal the connective tissue of a post-hæmorrhagic organization. In neither did the microscopical examination show any evidence of hæmorrhage or of any inflammatory reaction.

Virchow believed the cysts are produced by congenital anomaly of development in the formation of the diverticulæ of the cavities of the brain. Schüle believed the simple cyst originates from displaced embryonal cells in the embryonal life. That a transition between the simple cyst and that as-

sociated with mural tumors is possible and they may or may not be in communication with the fourth venticle. They are or are not covered by an ependymal epithelium. They appear in young persons (twenty to forty years). Antoni in reporting three examples of simple cysts of the cerebellum speaks of them as syringomyelia of the cerebellum and argues in favor of their formation on the same basis. As in syringomyelic cavities, the cysts are located behind the normal cavities in the dorsal portion of the primitive embryonal tube. Wersiloff (1913) has seen a cerebellar cyst associated with syringomyelia.

Because of the absence of neoplastic tissue, the author does not believe that simple cysts originate from a glioma (gliomatous cystic degeneration). He believes they take their origin from the ependymal canal in the embryo and are essentially congenital defects. The absence of an epithelial membrane is not an absolute argument against their congenital origin because it may disappear later. The subsequent thickening of the cystic membrane may be secondary to the pressure of the intracystic fluid.

Admitting the congenital origin of the cyst, it is not unreasonable to assume that trauma or other secondary factors may stimulate more active cell proliferation, or occasion an increase in intracystic pressure by closing the communication between the cyst and the ventricle. For these reasons and because of the mid-cerebellar location of the cyst a non-communicative hydrocephalus eventuates with signs of increased intracranial pressure and signs of cerebellar dysfunction.

The difficulties attending localization of simple cysts should be considered as an indication for early exploration rather than for postponement or procrastination. This view has been entertained even before the days of ventriculography. The latter may be essential to determine the exact localization and, if during the ventriculography, severe signs of medullary compression appear, the patient should be put in the prone position with head lowered on a Ferguson's frame. The ventricle should be tapped and hyperglucose given intravenously. Preparation should be made to operate without delay.

A suboccipital exploration is made with the removal of one or two cervical laminæ with exploration of one or both cerebellar hemispheres with a brain canula. If a cyst be found it is opened and explored. To verify the true nature of the cyst a specimen of the wall is removed for microscopical study. If the lesion prove to be a benign cyst simple decompression followed by evacuation of its fluid and swabbing of the wall with Zenker solution or a solution of iodine may eventuate in a permanent cure. Neisser and Pollak (1907) recorded a radical cure after fifteen successive taps during a period of fifteen months.

If the cyst be small, total excision of the cyst wall may be attempted. The mortality following operations on simple cysts should be negligible and the ultimate prognosis excellent when the patient is operated upon before the onset of a cerebellar crisis.

CONCLUSIONS

1. Two cases of benign cyst of the cerebellum are reported with a discussion of their nature, their symptomatology, and the differential diagnosis from tumors and other lesions of the posterior fossa.

2. In one of the two cases there were found at necropsy, as a complication, multiple duodenal ulcers.

3. A classification of cerebellar cysts is presented.

4. Benign cysts of the cerebellum are exceedingly rare and the diagnosis can be certified only after a careful microscopical examination of the cyst wall.

5. The treatment is surgical and the appropriate procedure is outlined.

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UNCLASSIFIED ORGANIC PSYCHOSIS

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Cases showing unusual clinical features which cannot be satisfactorily correlated for diagnosis are of interest. When such cases can be studied pathologically and show changes which do not fit into any classifiable pathological group they should be recorded. We wish to report such a case.

Case Report.—The patient was thought to be normal until about four months before admission to the hospital in March, 1932. In December, 1931, she lost her position; this caused her to worry; she became irritable and manifested attacks of negativism. In January, 1932, she "went to pieces." She began having convulsive attacks and "cramps" and complained of being weak after each of these attacks. She was so weak she could scarcely get out of bed. She slept most of the time, became irrational, had delusions and on occasions refused to eat. She would have unexplained emotional upsets. There was a progressive loss of interest in her surroundings and she finally no longer controlled her bladder and bowel movements. One of her delusions was that she had given birth to a child, although she had never been pregnant. Little was known of her early history. Presumably she made normal progress in school. She was employed as a domestic before and during her married life. At the age of thirty-six she had an operation for appendicitis and at forty an attack of influenza. She complained of having a great many severe headaches; the location and type of pain are not recorded. Her family history was apparently entirely negative. She had been married twice, but had had no pregnancies. Her second marriage was at the age of thirty-eight and apparently was happy until the husband developed "muscular rheumatism," making it necessary for the patient to work. Her habits were apparently good and no peculiarities of personality were noted until the development of the present illness.

Physical examination at the time of admission in March, 1932, showed a patient who was undernourished and weak, and who apparently could not control her vesical or rectal sphincters. The neurological examination showed difficulty in the use of the lower extremities. Her gait was unsteady, her movements were all fumbling and jerky. She was unable to carry out coördination tests. She was able to localize tactile sensation and to discriminate sharp from dull stimuli. Her sense of position and stereognostic sense were apparently not disturbed. She was unable to write. The left pupil was definitely larger than the right and the light reaction was present on the right, but absent on the left. The palpebral fissure was not completely closed on the right side during sleep and the mouth tended to droop to the right. She drew back the left side of the face better than the right. The tongue was unsteady. There was considerable slurring of test words. The hands were partially closed and there was generalized motor weakness. The patient was somewhat stuporous and wanted to sleep most of the time. There was a peculiar rotary movement of the right arm and hand, which was partially under the patient's control. The knee-jerks were not obtained. Plantar stimulation gave flexion on the right and extension of the great toe with flexion of the others on the left. The Kahn test on the blood was reported negative. The cerebrospinal fluid Kahn test was questionable. There were thirteen cells and a gold sol curve of 11223220. This was not repeated. April 4, 1932, an eye examination was made, which was reported as follows:

Exophthalmos of both eyes, more marked on the right. Some weakness of the external recti, more marked on the right. Divergent squint of the right eye. A slight amount of swelling in the upper margin of the disk in the right eye. This was suspected of being a beginning choked disk. The left eye showed a choking of about two diopters. July 28, 1932, she was presented before the staff of the Pontiac State Hospital as a questionable brain tumor, probably of the right frontal lobe. September 19, 1932, an eye examination showed atrophy of the right optic nerve with dimming of the outlines of the disk and evidence of secondary optic atrophy. The left eye was similar and there was no choking of either disk. The consultant considered that brain tumor was not a likely diagnosis inasmuch as the choking had decreased.

September 23, 1932, we examined the patient. The patient was seen lying in bed and there was an apparent right spastic hemiparesis. There was considerable retraction of the head. There was marked generalized wasting of the body. She appeared to complain of pain in the top of her head. The skin was greasy. There was considerable

FIG. 1.—Multiple cysts in basal ganglia of the left lobe, pronounced demyelinization in centrum semiovale and the temporal lobe; numerous myelin islands preserved. U-fibres frequently destroyed.
Weigert stain, half normal size. Photograph.

proptosis of both eyes, which was more marked on the left than on the right. The pupils were moderately dilated, irregular; reaction to light and in accommodation could not be tested. The ocular fundi showed moderate secondary optic atrophy. The extra-ocular movements could not be satisfactorily tested. There appeared, however, to be a slight difficulty in rotation of the eyes to the left and a nystagmoid movement on lateral deviation. She did not rotate the eyes completely to the right, but there was no nystagmoid movement on rotation in this direction. There appeared to be some weakness of the right side of the face. The patient attempted to protrude the tongue, but could not get the tip of the tongue beyond her lips. The upper extremities both showed marked hypertonicity. The arms were both held flexed at the elbow and at the wrist. The reflexes were hyperactive. There was marked hypertonicity of the muscles of the lower extremities, which was associated with muscular wasting. There was also contraction in flexion of the lower extremities. The reflexes were hyperactive, but difficult to obtain because of marked contraction. There was a positive Babinski sign on both sides. Positive Oppenheim, Schaffer, Gordon and Chaddock signs were noted on both sides.

Pain sensation appeared to be felt better upon the left side than upon the right side of the body. Tactile sensation appeared to be the same on both sides, although it was impossible to be sure because of lack of coöperation on the part of the patient. She had considerable difficulty in making any movements of the extremities, although if her legs were partially extended she was able to flex them. The abdominal reflexes were active in all four quadrants. From this examination, we considered that the patient had a diffuse degenerative cerebral condition. The patient became progressively worse and died November 25, 1932.

Summary.—The patient, a female of thirty-six years, of Canadian-Irish descent, of perhaps slightly subnormal intelligence, developed a condition associated with a psychotic trend of delusions, melancholia and irrationality with confusion associated with definite organic findings, such as convulsive attacks, increased reflexes, pathological reflexes, but with such disseminated findings that localizing diagnosis was impossible. It is interesting to note that during the course of the disease process there was observed an apparent

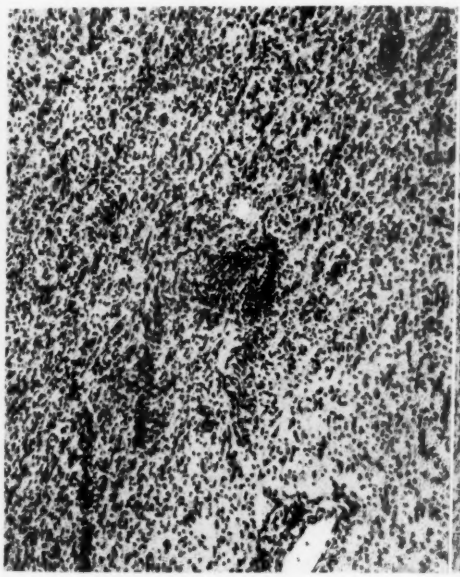

FIG. 2.—Scar formation in the right frontal region; note perivascular infiltration and enormous cell content.
Nissl stain, x50. Microphotograph.

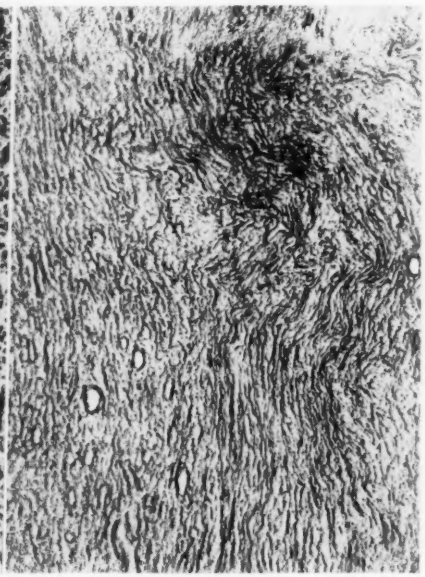

FIG. 3.—Dense connective-tissue network in the scars.
Perdrau stain, x50. Microphotograph.

increase in intracranial tension with papillœdema of two diopters which receded and was followed by secondary optic atrophy. This would suggest the presence of an inflammatory process. Many of the pathological changes must likewise be explained as the result of inflammation. The condition must be considered therefore to be some bizarre type of encephalitis. Post-mortem was allowed only on the brain and spinal cord.

Gross examination of the brain and spinal cord.—The brain was of approximately normal size and weighed 1,240 grams. The meninges showed no gross pathology; the blood-vessels appeared normal. The convolutions were well developed. On frontal section, the gray matter was of normal width and appearance. There were several small yellowish foci in the gray matter of the left frontal lobe. The caudate nucleus of the left side, as well as most of the putamen and pallidum, was destroyed and replaced by several large cysts (Fig. 1). The uncus and Ammon's horn on both sides were greatly shrunken and yellowish in color. The anterior part of the left thalamus appeared atrophic. The right caudate nucleus and putamen were somewhat shrunken and in the pallidum there

was a yellowish focus as large as a lentil. The lateral and third ventricles were moderately enlarged. The white matter of both hemispheres showed no gross changes. The brain stem, pons, medulla and cerebellum were apparently without gross pathology, while the spinal cord showed only mild hyperæmia of the gray matter.

Microscopical examination.—The larger cystic cavities in the basal ganglia contain no tissue except for occasional tissue bridges traversing them. The walls of the cavities and the scar tissue, in general, show, on the contrary, a very complicated structure. Narrow arms of the cavities are filled with a fine network of connective tissue and glial fibres containing a few large astrocytes and polyblasts of different shapes, mostly laden with greenish pigment or fat globules. The scar tissue appears dense and the cells more numerous the farther they are from the cavity (Fig. 2). The connective-tissue fibres arising from the adventitia outnumber greatly those of glial origin (Fig. 3); the blood-vessels are numerous, all of them showing a very considerable proliferation of the adventitia, infiltration with lymphocytes and swelling of the epithelium, which culminates in occlusion of the lumen (Fig. 4). Examination with high power reveals that the

FIG. 4.—Occluded and infiltrated vessel in the scar tissue of the subthalamic region. Nissl stain, x50. Microphotograph.

FIG. 5.—Multiple scars in the putamen, pallidum and subthalamic region. Right lobe. Ammon's horn shrunken. Nissl stain, x2½. Microphotograph.

majority of the cells in the adventitia are polyblasts so that the structure produced resembles a small granuloma. Many areas of hyaline degeneration of the media are seen. The surrounding scar tissue also contains polyblasts interspersed with large atypical Alzheimer glia elements and large astrocytes, making the morphology of the cell types almost inexhaustible. The polyblasts are represented by all transitional types from the fine elongated mesenchymal variety to the round Gitter cell.

The Alzheimer glia mostly consists of kidney-shaped, deeply stained nuclei the size of a Gitter cell with either a scanty, irregularly shaped protoplasm, or apparently with none. Numerous lymphocytes and plasma cells accumulated in perivascular spaces, or filling the tissue structures, give the affected areas the appearance of a chronic inflammation (Figs. 2 and 4).

The histological type of the disturbance in the basal ganglia is not the same on both sides. The cavities occur upon the left and the scarring on the right (Fig. 5), but upon both sides putamen, pallidum and caudatum are almost entirely destroyed while both

thalami are penetrated by multiple scars, although a considerable amount of parenchyma remains. The internal capsule on the left is involved in the cavity formation while that on the right is scarified. The hypothalamus, red nuclei, the subthalamic bodies, the central gray substance and the reticular area contain occasional scars. The substantia nigra, pons, medulla, cerebellum and spinal cord are free of changes. There is a secondary atrophy of the optic nerve.

The gray matter of the left frontal lobe contains numerous scarified foci of the same histological structure as those seen in the basal ganglia on the right side with the exception that the lesion usually breaks through the limiting glial layer involving the leptomeninges, which appear greatly thickened over the lesion. This change is, however, a strictly limited one, the brain covers being otherwise not disturbed. There are occasional microscopical scars throughout both hemispheres. The gray matter also contains a slight proliferation of the blood-vessels, with occasional lymphocytic infiltration near the larger lesions. The blood-vessel system is otherwise undisturbed. The glia activity is insignificant; cyto-architectural disturbances are limited to the region of the lesions; elsewhere the neurones show only slight non-specific chronic changes.

There is a marked change of the same type as that seen in the basal ganglia involving Ammon's horn and uncus of both sides. These areas contain numerous scars (Fig. 5), the parenchyma being greatly reduced, while some of the neurones are calcified. The blood-vessels are frequently occluded, as above described, and there were countless microglia cells and astrocytes. In contradistinction to cortex and basal ganglia, the repair is carried out predominantly by glial fibres, the connective-tissue production being minimal.

The white matter of both hemispheres contains scattered foci of glial response containing astrocytes, oligodendroglia and Alzheimer glia. For the most part these changes are related to the lesions of the cortex and basal ganglia. The vascular system does not appear to be involved other than above described.

The true extent of the myelin destruction is revealed in Weigert sections (Fig. 1). The basal ganglia, the internal capsule and the temporal lobes are almost completely demyelinated while the centrum semi-ovale still contains multiple myelin islands. These are occasionally perivascular in character, but for the most part such a relationship does not seem to exist. Although the superficial layers are somewhat better preserved than the deeper ones in all areas the U-fibres show demyelinization. The rarefied areas are not quite void of myelin containing a few preserved myelin sheaths, along with multiple myelin balls and disintegrating fragments. Lipoids are practically absent, being restricted to a few granules taken up by scattered Gitter elements. Arteriosclerotic, syphilitic or tubercular changes are not seen.

Summary.—Grossly the case is characterized by the formation of cavities destroying caudatum, putamen and pallidum upon the left side, and a scar formation of the same areas on the right. There are several gross lesions in the gray matter of the left frontal lobe. Microscopically the lesions consist of a peculiar scar tissue of mixed glial and connective-tissue origin, occlusion, swelling and infiltration of the blood-vessels and scattered scars in the cortex of both sides. Both Ammon's horns and uncus formations are greatly shrunken. The parenchyma of the basal ganglia is almost entirely destroyed. The Weigert sections reveal a peculiar demyelinization involving the basal ganglia, the semi-oval centres and the temporal lobes.

DISCUSSION

The analysis of the histological picture suggests an initial affection of the blood-vessels. The peculiar proliferation of the adventitia, culminating in the occlusion of the blood-vessels, seems to be an independent condition, which very soon influences the surrounding gray and white matter, producing

either cavities or extensive scar formation. Apparently the affection must be considered inflammatory in origin because of the presence of countless perivascular lymphocytic and plasma-cell infiltrations.

The histological structure of the scar tissue, which can be properly designated as granulation tissue, is an unusual one. So intimate a relationship between connective tissue and glia in an inflammatory condition occurs very rarely, and is not known so far in affections preferring the basal ganglia, as in the case in question. Arteriosclerotic changes are out of the question since this type of blood-vessel affection is entirely absent, and arteriosclerosis never produces inflammatory changes. There is little reason to believe that syphilis is responsible for the described changes. The serology is presumably negative and there are no signs of blood-vessel or parenchymatous syphilis.

The presence of numerous Alzheimer glia cells may suggest a condition related to the Wilson group, but such an interpretation would disagree with the clinical picture and the presence of an inflammatory reaction. Furthermore, the Alzheimer glia may be encountered in a variety of chronic brain diseases of different etiologies not related to the Wilson group (A. Jacob).

The rather extensive demyelination suggests the comparison with the group of diffuse sclerosis. The majority of the observations of that type, however, can be excluded because the myelin destruction in diffuse sclerosis goes on with the production of enormous amounts of lipoids, no myelin islands remain, no cavities are produced and there is no tendency to localize mainly in the basal ganglia. A certain resemblance, however, seems to exist between this and a few observations of atypical changes. The first one is that of Lowenberg and Fulstow in which a rather extensive glial and connective-tissue scar-formation was found and no fat was produced; at the same time the observation presented an accumulation of peculiar metabolic products so that the cases cannot be identical. The second observation is that of Lowenberg and Hill of so-called diffuse sclerosis with preserved myelin islands, presenting certain similarity in the Weigert sections, but lacking in scar and cavity production. There is, however, no definite resemblance to concentric sclerosis as reported by Waggoner and Lowenberg.

In reviewing the literature of so-called non-classifiable observations in mental diseases (compare Hallervorden) we find no parallel observation and are compelled therefore to regard the case in question as a non-classifiable one, both from the clinical and pathological viewpoint.

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THE EFFECT OF LESIONS OF THE HYPOTHALAMUS UPON THE GASTRO-INTESTINAL TRACT AND HEART IN MONKEYS

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In his Balfour Lecture delivered in Toronto in 1931, Cushing[1] drew attention in a striking manner to the neurogenic factors involved in the formation of gastro-intestinal ulceration. He described cases of intracranial tumor which had been associated with perforation or ulceration of the gastro-intestinal tract, and he gave an exhaustive review of the literature on the subject. A short time later, while studying the relation of the hypothalamus to heat regulation, Keller discovered that after hypothalamic lesions a number of his cats died of peritonitis due to perforation of the stomach or duodenum, and with Hare and D'Amour[2] (1933) Keller subsequently described the marked vascular changes which occur in the gut of cats and dogs following hypothalamic injury, together with the cardiac disturbances which also appear after such lesions. It has seemed desirable, therefore, to observe the effect of localized lesions of the hypothalamus upon the heart and gastro-intestinal tract of higher forms. The present report is based upon a study of seventeen monkeys, chiefly *Macaca mulatta*, which had been subjected to various types of hypothalamic injury.

Method.—Animals were chosen which were feeding well and were without signs of gastro-intestinal disturbance. They were all maintained on the standard laboratory diet for monkeys, made up of fruit, cooked vegetables and "chimcracker" (Tinklepaugh[3]), which in normal circumstances keeps the stools firm and well formed.

Operation.—The hypothalamus was generally exposed by the transcallosal route. Under intraperitoneal or intramuscular (given to avoid the criticism that the gut might be affected by the intraperitoneal injections) sodium amytal anæsthesia, a large bone flap was elevated extending just across the longitudinal sinus and the cortex exposed through reflection of a medially attached dural flap. After coagulating one or more superior cerebral veins with a Davis-Bovie unit, the hemisphere was gently retracted to expose the corpus callosum. The anterior cerebral artery, which in the monkey is a single trunk that sends branches to the medial aspects of both hemispheres,[4] sometimes formed an obstacle. However, it was found that individual branches or the main trunk could be ligated and cut without producing motor deficit or change in behavior of the animal.[5] An incision four to five millimetres long was made in the corpus callosum with a spatula. In some instances the third ventricle was pierced directly; in others after entering the lateral ventricle, the foramen of Monroe was identified, and a small probe inserted through this foramen into the third ventricle. The lesions of the hypothalamus were made by inserting a probe through the floor of the third ventricle, or sucking out a small portion of the hypothalamus with the suction apparatus, or by coagulation with the Davis-Bovie electrosurgical unit. In two animals the hypothalamic lesion was

made by the subtemporal approach, and in two a silver clip was placed on the pituitary stalk. No attempt was made to study changes in blood or urine chemistry.

Autopsy.—The animals were sacrificed (except for four that died during the night) at intervals from a few days to nine months, and careful post-mortem examinations were made immediately (begun under anæsthesia) with especial attention directed to the gastro-intestinal tract and heart. After opening the peritoneal cavity and inspecting the viscera for evidence of infection and perforation, the abdominal and thoracic viscera were removed *in toto*, including the œsophagus and rectum. The alimentary tract was removed from the surrounding viscera and its mesentery without touching the gut with forceps or clamps. It was then opened and minutely inspected. Abnormal areas, after being drawn or photographed, were taken for microscopical study, and serial sections of the diencephalon stained by Nissl or Spielmeyer technics were cut to determine the exact extent of the lesion.

Controls.—It was evident that a careful study of the gastro-intestinal tract of monkeys under laboratory conditions must be made to serve as a background for interpreting changes that might follow lesions in the hypothalamus. For this purpose one of us (J. W. W.) performed complete autopsies, in the manner previously described, upon sixty-three animals (monkeys, baboons and chimpanzees) without hypothalamic lesions that died or were sacrificed in the laboratory during the year. Of the seventeen hypothalamic animals a clip was placed on the pituitary stalk in two, and in fifteen some portion of the hypothalamus was destroyed. The majority of the remaining sixty-three post-mortem examinations were made upon animals which had undergone operations upon some other part of the brain or the spinal cord.

RESULTS OF EXPERIMENTS

Apart from sluggish behavior, drowsiness and occasional transient polyuria and adiposity, the chief abnormalities observed following hypothalamic lesions lay in the activities of the gut and heart. Evidences of impaired function of both systems were seen during life. The pathological changes responsible for these abnormalities in the case of the gut may be grouped under five headings: erosions, perforations, bleeding, punctate hæmorrhage and chronic ulcers. The cardiac disturbances will be discussed separately.

Gastro-intestinal Disturbances.—It is significant that a much higher proportion of acute gastro-intestinal changes were found following hypothalamic lesions than after lesions elsewhere in the nervous system. Though careful examinations of the gastro-intestinal tracts were made in only sixty-three control animals, routine autopsy examination of the stomach and gut had previously been made in this laboratory in over 300 monkeys and apes after cortical and spinal lesions without disclosing consistent changes—a circumstance which lends even greater statistical significance to the following observations:

Erosions of the mucosa, as Keller, Hare and D'Amour[2] reported, are one of the prominent changes following hypothalamic injury. Sharply circumscribed, punched-out erosions were encountered in five animals, four of which had been subjected to hypothalamic lesions. The only animal without a hypothalamic lesion in which erosions were found had received daily injections of ephedrine after mid-thoracic transection of the spinal cord. These five animals will now be described.

Experiment 1 (Hypothal. 2).—Mature male Macaca mulatta weighing 6,250 Gm. Bilateral destruction of tuber nuclei; drowsiness, loss of weight; sacrifice on eleventh day; deep erosion of pylorus.

The motor foot area of this monkey had been removed bilaterally four months previously, and the left premotor area a few weeks later (June 30, 1932) after which appetite and general condition were good, though some loss of weight occurred. October 15, 1932, by the transcallosal route, a large hypothalamic lesion was made destroying the tuber nuclei bilaterally. After operation the animal was drowsy and for several days had a staggering gait. Though its appetite appeared good its general condition deteriorated and it had lost 1,500 Gm. in weight when it was sacrificed on the eleventh day after the operation.

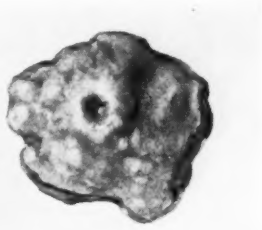

FIG. 1 (Experiment 1).—Drawing of the circumscribed mucosal erosion in the pylorus which occurred in this animal.

At autopsy which was begun under Dial anæsthesia a sharply circumscribed erosion 2.5 millimetres in diameter and 1.5 millimetres deep with hæmorrhage into the base was found in the pylorus (Fig. 1). Microscopically, there was sharply defined necrosis of the mucosa, extending almost to, but not involving the muscularis (Fig. 2). No thrombi were found in the surrounding blood-vessels, nor was there any sign of inflammation or repair about the necrotic mucosa. The small erosion was on the lesser curvature of the stomach but the rest of the stomach mucosa was normal.

Serial sections of the hypothalamus indicated that the tuber and anterior part of the

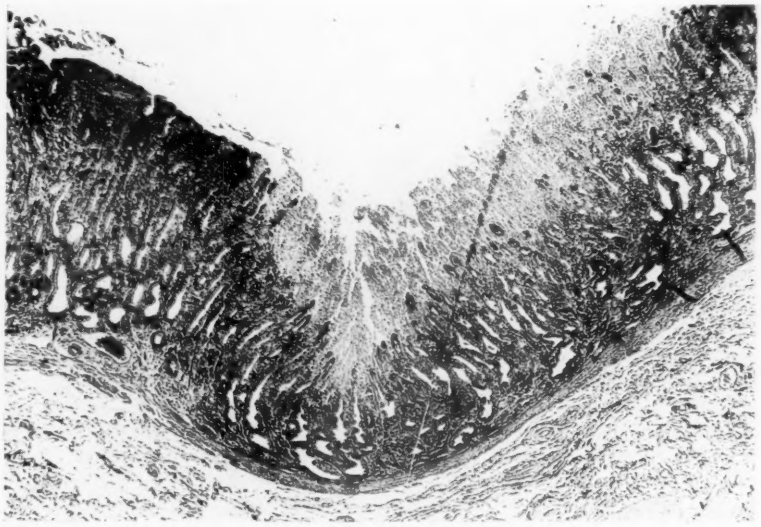

FIG. 2 (Experiment 1).—Photomicrograph of a section through erosion in Fig. 1 showing well-defined necrosis of the mucosa. The muscularis is not involved. H. and E. stain; magnification × 56.

paraventricular nuclei had been destroyed on both sides, the lesions extending slightly more to the left side than the right.

Experiment 2 (Hypothal. 9).—Male Macaca mulatta weighing 4,000 Gm. Large symmetrical hypothalamic lesion; sacrifice after twenty-five days; deep erosion in stomach, hæmorrhagic areas in large intestines, and old perforation.

November 12, 1932, in a healthy young male macaque, a large unilateral lesion was

made with sucker by the transcallosal route. The lesion involved most of the supra-optic, tuber and paraventricular nuclei; it also encroached slightly upon the internal capsule. After the operation the animal had a right hemiparesis and hemianopsia from which it gradually recovered. It showed slight drowsiness but no polyuria and the animal's general condition and its appetite were excellent throughout the post-operative period. It was sacrificed December 7, 1932, having lost 240 Gm.

At autopsy a sharply circumscribed punched-out erosion two by one millimetres was found in a mucosal fold of the stomach situated about two centimetres from the lesser curvature and five centimetres from the pylorus. It was hæmorrhagic and its gross and microscopical appearance were similar to that described in the preceding experiment. The duodenum and small intestine were normal but two large hæmorrhagic areas were found in the large intestines affecting the mucosa over about one centimetre in each instance. In the transverse colon was a prominent cicatrized area, evidently recent, which pulled the surrounding mucosa into folds like a purse-string. Over this area were peritoneal adhesions.

Serial sections of the region of the third ventricle indicated a large unilateral lesion which affected the tuber nuclei primarily. There had been hæmorrhage in the third ventricle.

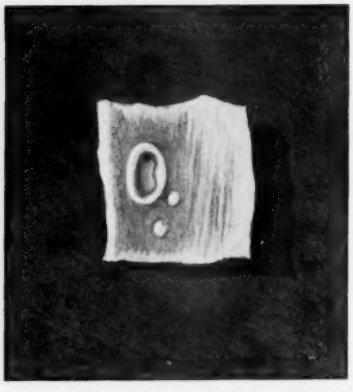

FIG. 3 (Experiment 4).—Drawing of an erosion in the lower third of the œsophagus.

Experiment 3 (Hypothal. 16).—Immature Macaca mulatta weighing 3,950 Gm. Large hypothalamic lesion; stupor with passage of undigested food; death after eight days; multiple hæmorrhagic erosions on lesser curvature of stomach.

February 8, 1933, the third ventricle of an active young macaque was exposed by the transcallosal route, and by suction a large mid-line lesion was made immediately overlying and extending anterior to the optic chiasm, destroying most of the supraoptic nuclei, few of the tuber but none of the paraventricular groups. Following operation no motor deficit and no ocular symptoms were present, but the animal sat with head lowered between its knees, with little interest in its surroundings or in food. On the third day its weight had dropped to 2,650 Gm. and it was observed that its stools were blood-streaked and contained large amounts of undigested food which looked more like food run through a meat grinder than that which had passed from the intestinal tract. The general course was downward and death occurred on the eighth post-operative day.

At autopsy, which was done about four hours after death, multiple shallow, definitely defined erosions 0.5 to 1.5 millimetres in diameter were present in the lesser curvature and cardiac end of the stomach. Microscopically, the erosions overlay submucous nodules. In the crater of each was débris composed of lymphoid cells and fragments of mucosa. There was no evidence of reaction about the periphery of the erosion. The duodenum and intestines were normal. The lungs and spleen showed evidence of early miliary tuberculosis. In the left side of the heart was a thrombus, probably post-mortem in character.

Experiment 4 (Hypothal. 10).—Female Macaca mulatta weighing 4,300 Gm. Large hypothalamic lesion made with cautery; attacks of syncope and irregular pulse; death on fourth day; erosions in œsophagus and stomach; pre-mortem clot in heart.

In a well-nourished macaque under amytal anæsthesia (administered intramuscularly) by the transcallosal route, a large unilateral lesion was made in the hypothalamus November 17, 1932. It was made with a hot needle and extended from the anterior commissure to the basis pedunculi, thus destroying portions of the supra-optic,

tuber and paraventricular groups of nuclei chiefly on the left side. The anterior limb of the internal capsule was also damaged. The day after operation, the animal vomited

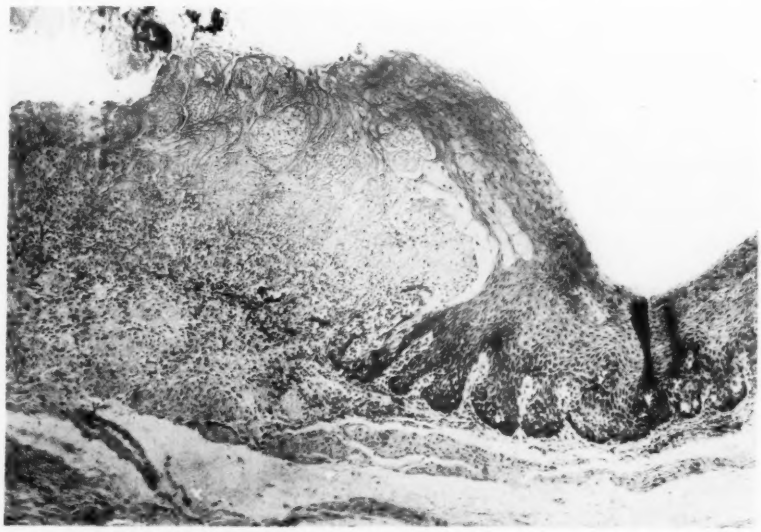

FIG. 4 (Experiment 4).—Photomicrograph of the erosion shown in Fig. 3, seen extending through the entire mucosa. Inflammatory elements predominate, but repair is beginning. H. and E. stain; magnification × 110.

and was found lying on its side in the cage, just as it had been placed. It had a right hemiparesis. When the monkey was elevated to the sitting position, the respirations became labored, precordial pulsation which was visible became forceful. Within a minute the pulse became faint, the respirations ceased, the eyes closed, the head fell forward and the extremities became limp. The animal appeared dead, was laid on the floor of the cage, but in a few minutes recovered. This performance was repeated on three other occasions when the animal's head was raised well above the body. Cardiac irregularities with extrasystoles were present throughout the post-operative period. Death occurred on the fourth day.

FIG. 5 (Experiment 4).—Drawing of the pre-mortem thrombus filling the right auricle and extending into the ventricle and great vessels.

Post-mortem examination, carried out about five hours after death, revealed an oval erosion with elevated edges six by eight millimetres in diameter in the lower third of the œsophagus (Fig. 3). Microscopical examination showed that the erosion entered the muscularis (Fig. 4). Within the crater were blood, fibrin, lymphocytes, polymorphonuclear cells and some fibroblasts and new blood-vessels. Epithelium was beginning to grow over the edges of the crater. The lower end of the stomach showed multiple punctate submucosal hæmorrhages, but the intestines were normal.

In both chambers of the heart were large pre-mortem clots (Fig. 5) that in the

right side almost filled the auricle as well as a considerable part of the ventricle, which accounted for the syncopal attacks.

Experiment 5 (Ephed. 25).—Young female Macaca mulatta weighing 2,150 Gm. Spinal transection; prolonged administration of ephedrine; multiple punched-out erosions in duodenum.

Following a mid-thoracic transection of the spinal cord (February 13, 1933) in a young poorly nourished macaque, daily injections of ephedrine were given for seventy days to study its effects upon spinal reflexes. The animal gradually lost weight and was emaciated at the time it was sacrificed (May 24, 1933). In the duodenum just below the pylorus were numerous round and irregularly shaped, sharply defined erosions one to two millimetres in diameter. As in Experiment 3, they lay over submucous collections of lymphoid cells and did not extend beyond the mucosa. In the cæcum were erosions with a similar appearance, except for the presence of free blood in the lumen overlying them. They differed microscopically, however, from those in the duodenum. There was evidence of an old inflammatory process in the mucosa at the site of the erosions and in the intervening mucosa of the cæcum.

No one of the first four experiments could be regarded as significant in itself, but taken together they constitute a suggestive body of evidence indicating a causal relation between hypothalamic injury and gastro-intestinal erosions. They were relatively long-term experiments and further observations are needed with (1) earlier sacrifice and (2) more precisely localized lesions. The ephedrine experiment may also be significant, if release of vasoconstriction innervation of the gut is a factor in ulcer formation.

Only one perforation of the gut with resulting peritonitis was encountered during the year, and this occurred in an animal with a hypothalamic lesion. Its history is as follows:

Experiment 6 (Hypothal. 1).—Mature male Macaca mulatta weighing 6,850 Gm. Large hypothalamic lesion; somnolence; perforation of duodenum on seventh day, peritonitis, death.

October 7, 1932, the tuber and paraventricular nuclei of a large well-nourished monkey were destroyed by electrocoagulation. There was some involvement of the internal capsule and the lesion involved the left nuclear masses more than the right. Following operation the animal had a right hemiparesis, appeared somnolent and uninterested in its surroundings. During the first days it fed well, but on the seventh day refused food and death occurred on the eighth day after a vomiting seizure in which blood was brought up. There was coffee-ground vomitus around the mouth.

Autopsy examination was made about four hours after death. When the abdomen was opened, a generalized purulent peritonitis was seen. Further examination disclosed a small perforation of the duodenum three centimetres distal to the pylorus with thin ragged edges and very little reaction. The surrounding mucosa was digested and ischæmic in appearance. The stomach was filled with coffee-ground material. The rest of the stomach and intestinal mucosa was not remarkable. The animal had evidently been in perfect health prior to operation.

In more than 400 autopsies on monkeys and other primates following a great variety of surgical procedures (with anæsthetic administered by the intraperitoneal route), this is the only instance of peritonitis from perforation that has been encountered. The purulent character of the peritonitis indicates that the perforation was pre-mortem.

Free blood in the lumen of the gut was encountered five times. It oc-

curred twice in animals after hypothalamic lesions, twice in monkeys with mid-thoracic transections of the spinal cord, and once in an animal from which both premotor areas had been extirpated.

Experiment 7 (Hypothal. 7).—Mature Macaca mulatta weighing 5,400 Gm. Small hypothalamic lesion made in attempt to clip pituitary stalk; passage of blood; death on tenth day; free blood in bowel.

November 1, 1932, in an attempt to place a silver clip on the pituitary stalk of a healthy adult macaque the stalk was missed and two small areas of softening were subsequently found in the hypothalamus one millimetre from the mid-line just posterior to the tuber cinereum. A right hemiparesis was present the day following operation and right-sided focal seizures occurred on the third day. On the fourth day the convulsions ceased, but during the next few days the animal gradually grew weaker, ate and drank little, and lay sprawled in the cage. November 3 and November 9, fresh bloody mucus was seen around the rectum. The animal refused food on the ninth day and took only a few swallows of water. The next morning it was found dead in its cage.

The autopsy was performed within four to five hours of death. The gastric mucosa was normal but in the duodenum were many pinpoint hæmorrhages. The intestines appeared normal. The cæcum and colon showed large hæmorrhagic areas increasing in size as the rectum was approached. The rectum presented a reddish appearance, with the crests of the mucosal folds and circumscribed hæmorrhagic areas two to three millimetres in diameter standing out in brighter red. Free blood was present in the lumen of the rectum. Microscopically, there was sloughing of the superficial layers of rectal mucosa; a thin layer of débris composed of degenerated cell columns and inflammatory exudate covered the eroded area.

Though it is conceivable that this animal had colitis before operation, its pre-operative stools were normal, and there was no evidence of blood. The lesions found after operation were evidently fresh, and the bleeding certainly recent. Free blood was also found in Experiment 5. In the next experiment bleeding occurred some weeks after bilateral removal of the motor and premotor areas of the cortex, a procedure which has also led to other forms of gastro-intestinal disturbance.[6]

Experiment 8 (Premotor 15).—Female Macaca mulatta weighing 3,300 Gm. Bilateral ablation of motor and premotor areas; five weeks later vomiting of blood and death.

The motor and premotor areas were removed from each hemisphere of a healthy macaque March 25 and April 11, 1933. The animal fed well but lost weight for five weeks; twenty-four hours before sacrifice (May 18, 1933) it began to vomit coffee-ground material. This continued, the pulse became rapid, and the animal very dyspnœic. It was accordingly sacrificed.

Autopsy was begun under anæsthesia. The stomach was full of blackish coffee-ground material, and similar blackish material was scattered throughout the small and large intestines. This material was more abundant in the upper portion of the small intestine and gradually diminished distalward. Though a very careful search was made for the source of bleeding, the only suspicious-looking areas found were several minute opaque spots in the pylorus which appeared like mucosa that had been touched with a cautery.

Experiment 9 (Ephed. 21).—Young Macaca mulatta weighing 1,550 Gm. Spinal transection followed by periodic injection of ephedrine; sacrifice; gross blood in colon.

Following transection of the spinal cord of a young macaque at the eighth thoracic level January 21, 1933, numerous injections of ephedrine were given to determine its

effect upon the reflexes. (Experiment 5.) The animal was sacrificed February 22, 1933, and when the transverse colon was opened, free blood was present in the lumen. This came from the margin of a slightly elevated inflammatory process three by fifteen millimetres in the wall of the gut. No other gross abnormalities were seen.

Of the other animals in the series two monkeys which died within a half hour of the time a part of the hypothalamus was destroyed (and which were not included in the seventeen herein described) had normal gastro-intestinal tracts. Three monkeys with bilateral lesions in the region of the tuber cinereum that died or were sacrificed within four weeks had normal gastro-intestinal tracts. Five monkeys, including two with clips on the pituitary stalks, that were allowed to survive between seven and eight months after hypothalamic lesions, had normal alimentary canals.

Punctate hæmorrhages unaccompanied by erosion of the mucosa and circumscribed hæmorrhagic areas a few millimetres in diameter, were present in 19 per cent. of the eighty autopsies, irrespective of the type of operation. They occurred with about equal frequency in the stomach, small intestine, and large intestine. In the terminal part of the ileum, in the cæcum and colon, thinned or roughened mucosa underlying hard fecal masses was encountered in the majority of post-mortem examinations.

One chronic peptic ulcer was found in the series of eighty autopsies and this occurred in an unoperated baby woolly monkey (*Lagothrix infumata*) which had been in the laboratory nearly a year, and had "cage paralysis." Upon one occasion when caught, it vomited copiously. The animal died and at autopsy was found to have a chronic ulcer in the first part of the duodenum which obstructed the lumen by cicatrization. The ulcer penetrated all coats of the intestine, but was walled off externally by adhesions.

Effects on the Heart.—Stethoscopic observations upon the heart rate were made during the operation in eleven animals. The heart invariably stopped when the lesion was being made in the hypothalamus. In some instances it stopped two to three seconds; in others, it stopped as long as twenty to thirty seconds. The heart then resumed beating slowly and irregularly 60, 80, 120; within a few minutes the heart might regain its normal rate of 130 or 140 per minute.

Two monkeys that died within a half hour of the time the lesion was made had both chambers of the heart filled with clots that appeared firmer than the usual post-mortem clot, and they were regarded as the cause of death.

One animal (Experiment 4) with a large unilateral lesion destroying the supra-optic, tuber and paraventricular nuclei presenting an unusual clinical picture, was described under "Erosions" and exhibited an extrasystolic arrhythmia. At autopsy a large firm clot was present in the right auricle, extending into the great vessels and into the ventricle (Fig. 5). The clot was firmly adherent to the walls. A smaller clot of a similar nature was present in the left chambers. The findings in the œsophagus have been described previously.

DISCUSSION

Our experiments indicate no definite relationship between the destruction of any single group of hypothalamic nuclei (supra-optic, tuber or paraventricular) and pathological changes in the gastro-intestinal tract. However, in every animal except one in which erosions of the alimentary canal were present a large hypothalamic lesion had been made. The post-operative condition of most of the animals having erosions was very grave; three died, one was sacrificed because death was expected within twenty-four hours, and one was in good condition when sacrificed. Only one animal not subjected to a hypothalamic lesion had mucosal erosions. This monkey, which had received repeated injections of ephedrine following a mid-thoracic transection of the spinal cord, was in a state of emaciation.

Although anorexia and poor general condition of the animal may predispose to the development of pathological changes in the alimentary tract, it should be borne in mind that the symptoms so often followed large hypothalamic lesions that they may be looked upon as part of the syndrome due to destruction of this area. Also, numerous monkeys in the control series died following operations upon other parts of the brain without developing such changes in the gut. It would appear, therefore, that large lesions in any part of the hypothalamus in monkeys may result in mucosal erosions, or even perforations of the upper gastro-intestinal tract. However, only one chronic peptic ulcer was encountered in the series of eighty autopsies, and this was in an unoperated animal.

Bleeding into the lumen of the alimentary tract was observed in five instances: twice in animals with hypothalamic lesions, once in a monkey with both motor and premotor areas removed, and twice in animals injected with ephedrine following mid-thoracic transection of the spinal cord. Punctate and focal mucosal hæmorrhages were seen as often in the control series as in animals with hypothalamic lesions.

The material presented in this paper throws very little light upon the ultimate mechanism of peptic ulcer formation, but we incline to the view that the erosions associated with hypothalamic injury are due to the action of gastric secretions upon areas of local ischæmia in the mucosa. Such ischæmic areas might result from mechanical activity of the gut or from excessive vasoconstrictor innervation. The drugs which cause active peristalsis also produce erosions (Light, Bishop and Kendall[7]), but we have observed in monkeys that vagal stimulation and the peristalsis-inducing drugs such as pilocarpine, cause increase in the vascularity of the stomach mucosa. Moreover, animals with erosions dying a few days after hypothalamic injury show a flaccid dilated stomach and gut (Sheehan and Hoff) similar in appearance to that found in death from ephedrine or adrenalin. Furthermore, marked erosions have been found in animals in which the lesion did not involve the posterior hypothalamic nuclei in which lies the chief vasoconstrictor representation of the forebrain. We believe, in other words, that

the erosions following lesions in the region of tuber and supra-optic regions are due primarily to local ischæmia incident to release or irritation of the guts vasoconstrictor innervation. This would also account for the cardiac irregularities, extrasystoles, *etc.*, which are entirely similar to those due to sympathetic hyperactivation.

SUMMARY

In a series of seventeen monkeys in which lesions of the diencephalon were made (involving the supra-optic, tuber and sometimes the paraventricular nuclei) many of the classical symptoms of hypothalamic injury occurred, including drowsiness, adiposity, cardiac and gastro-intestinal disturbances. The cardiac and gastro-intestinal abnormalities were singled out for special study and a comparison was made with sixty-three monkeys in which lesions had been made elsewhere in the brain stem. The observations are summarized above in the discussion, and from them we draw the following conclusions:

(1) Lesions of the hypothalamic area, and especially of the supra-optic and tuber nuclei are far more prone to cause profound gastro-intestinal disturbance with gastric and duodenal erosions, bleeding and even perforation, than lesions elsewhere in the nervous system.

(2) Such lesions also cause cardiac irregularities with a tendency toward death from intracardiac clotting (possibly fibrillation).

(3) We believe that the cardiac and gastro-intestinal symptoms are due primarily to release or irritation of the sympathetic and hence the vasoconstrictor innervation of heart and gut.

(4) Chronic peptic ulcers were not produced.

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APHASIA IN BRAIN TUMORS

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As a result of four years' intensive research on the problem of aphasia, 314 patients in whom aphasia was suspected were investigated and of these 234 were actually examined. Of this group sixty patients were selected for final analysis. The criterion for their selection was as follows: (1) The aphasia had to be clear-cut, that is, uncomplicated by any other disorder which might lead to changes in mental functioning; (2) the patient had to be under sixty years of age so as to eliminate the question of senility; (3) the mother tongue had to be English; that is, no person was included who first used a foreign language and acquired English secondarily; (4) patients who were blind or deaf were not included. The tests that were used were psychological and differed from any that have been used in previous work of this sort, although some of these tests were used by Goldstein and others in Germany. The work differs from similar research in the fact that inasmuch as the psychological tests had never been subjected to analysis in normal adults, a group of eighty-five selected adults were examined who were comparable to the aphasics in age, education, occupation and intelligence, so that it is to be understood that our results are always considered in the light of the performance of the median normal adult.

As a result of this work four classifications were adopted. These were predominantly expressive, predominantly receptive, expressive-receptive and amnesic. It is to be noted that there was no such thing as a clear-cut type of aphasia, for even in expressive and receptive cases they were preponderantly one or the other, and in all of our types of aphasia some elements of the other types were always in evidence.

The Nature and Location of the Lesions.—Of the sixty aphasic cases selected for critical analysis, one-quarter or fifteen, occurred in space-taking lesions. The study of speech disturbances in such conditions is of importance not only because of their relative frequency and their aid in locating the lesion, but because of the information they furnish in regard to the psychological phenomena occurring in rapidly changing pathological states. Moreover, these conditions offer the invaluable opportunity of examining a patient with or without speech disturbances previous to operation, with the certainty that some type of aphasia will follow a left-sided cranial operation in a right-handed individual, or *vice versa.*

From the standpoint of localization, the presence of speech disturbances may aid and in rare instances determine the site of the lesion; the absence is of less importance particularly if judgment as to the existence of aphasia is based on old methods of testing. Experience in this research has shown

TABLE I: ANALYSIS OF TUMOR CASES

No.	Age at First Hospital Admission	Handedness	Type and Location of Tumor	Symptoms before First Operation: Duration before 1st Operation	Symptoms before First Operation: Nature	Nature of Operation	Subsequent Course	Psychological Disturbances (Data taken from hospital records in parentheses): Pre-operative	Psychological Disturbances (Data taken from hospital records in parentheses): Post-operative
I. Expressive Group									
11	33	R.	Spongioblastoma multiforma of L. frontal, temporal and parietal lobes. (Necropsy)	10 yrs.: 7 yrs.: 3 yrs.: On admission:	Struck L. side head with baseball; unconscious 10 min. Attacks, numbness R. side face and shoulder. Weakness R. arm. Attacks, numbness and twitching R. neck and shoulder; possible R. facial weakness and weakness R. arm; paræsthesias R. face, arm, neck and chest; impaired hearing on R. with tinnitus both sides; headache.	*First:* Removal of portion of tumor in R. frontoparietal area. *Second:* 3½ yrs. later, removal of large portion of tumor under upper part of earlier opening.	*Post-operatively:* R. hemiparesis and marked aphasia, both of which improved greatly. After 3 yrs. increasing weakness of the R. side and aphasia; Witzelsucht. *Post-operatively:* Weakness and aphasia decreased rapidly. After a year and a half paralysis and aphasia again marked; death followed 3 mos. later.	(None.) (Marked aphasia; Witzelsucht before second operation.)	(Slight amount jocularity; marked aphasia.) Some jocularity. Moderate aphasia of expressive type with difficulty in articulation; some disturbance in the understanding of spoken language and printed material; great difficulty in writing and poor performances on Language Intelligence Tests. Some improvement during 2 weeks after operation.
34	27	R. from time he went to school, but originally L.	Probable calcified tumor in region of mesencephalon.	Age 6 to 21: 2 yrs.: On admission:	Dizziness and attacks of fainting; no unconsciousness; history of running L. ear. Frontal headache accompanied by nausea and vomiting. Tremor and slight weakness R. hand. Difficulty in speaking and writing. Discharging L. ear. X-ray: multiple calcified lesions just to L. of mid-line, in front of pineal region.	*Exploratory* operation over L. temporoparietal area, revealing nothing but increased quantity of spinal fluid.	*Post-operatively:* R. hemiparesis and marked aphasia, both of which improved rapidly. *Seven months after operation:* Slight R. hemiparesis with tremors in arm and leg; other findings as before.	(Difficulty in speaking and in writing, which may have aided in the localization.)	Severe aphasia of expressive type with great difficulty in articulation and word-formation; disturbances in the understanding of spoken language and printed material. Seven months after operation: aphasia very slight.
48	32	R.	Meningeal fibroblastoma of L. frontal and parietal lobes.	2 yrs.: On admission:	Weakness of R. arm followed in 2 mos. by weakness R. leg and gradually of whole side. Irritability and emotionalism. Nausea, vomiting, headache, disturbance of vision, tendency to drowsiness and some staggering on walking. Marked hemiparesis with increased reflexes and Babinski. Sensory disturbances on R. side, and astereognosis. Spinal pressure increased. Uncinate attacks with olfactory hallucinations. Bilateral choking and concentrically contracted fields with enlarged blind spots.	*First:* Large subcortical tumor in L. frontoparietal exposed. *Second:* Large and well-encapsulated tumor removed; extended from parietal lobe well into frontal and from cortex to base.	*Post-operatively:* Hemiparesis increased and marked aphasia developed. Improvement, with sudden decline after 2 mos. *Post-operatively:* Hemiparesis and marked aphasia with gradual improvement in the latter in the course of a year.	Irritability, emotionality, failing memory and slowness in expressing thought. No definite aphasic symptoms.	(Marked aphasia.) Severe aphasia of expressive type complicated by difficulty in evoking words and verbal confusions, and with serious disturbances in receptive functions. Retardation in response; occasional lapses when no response could be elicited; perseveration. Some tendency to foolish laughter.
49	43	L.	Glioma of R. fronto-tem-	9 wks.: On admis-	Headache, dizziness, nausea, vomiting. Weakness L. arm and leg. Reflexes bilat-	*First:* R. temporofrontal craniotomy with fulgar-	*Post-operatively:* Condition at first satisfactory but within a month	(Changes in personality; mentally confused; disori-	Mental condition at first good, but within a month

ization of a glioma. headaches returned and patient became progressively weaker. ented for time and place; tendency to jocosity. No definite aphasia.) marked degree of mental deterioration.)
Emotional. Severe aphasia

49	43	L.	Glioma of R. fronto-tem-	9 wks.: On admis-	Headache, dizziness, nausea, vomiting. Weakness L. arm and leg. Reflexes bilat-	*First:* R. temporofrontal craniotomy with fulgar-	*Post-operatively:* Condition at first satisfactory but within a month	(Changes in personality; mentally confused; disori-	Mental condition at first good, but within a month

			poral area.	sion:	erally increased, more on L.; bilateral Babinski, and ankle clonus on L. Possible astereognosis of L. hand. Spinal fluid under increased pressure. Hypersomnolence. Complete anosmia. R. pupil slightly larger than L. Beginning blurring of both discs. X-ray: pineal shifted downward, backward and toward L. side.	ization of a glioma. *Second:* 1 mo. later: large amount tumor and degenerative tissue removed from same area.	headaches returned and patient became progressively weaker. *Post-operatively:* L. hemiparesis and complete aphasia, with some improvement in both motor power and speech within a month.	ented for time and place; tendency to jocosity. No definite aphasia.) (Very little reaction to any stimulation.)	marked degree of mental deterioration.) Emotional. Severe aphasia of expressive type. Speech limited to a few sounds or words; writing very little better. Receptive functions limited but less disturbed than expressive.
59	55	R.	Subcortical cyst of L. central area: hæmangioma.	6 mos.: 4 mos.: On admission:	Tingling in R. face. Weakness R. hand, and then progressive weakness whole R. side. Spastic R. hemiplegia with increased reflexes, and ankle clonus but no Babinski. Diminution of touch, pain and heat sensibility in R. leg.	L. fronto-temporal craniotomy with evacuation of subcortical cyst just above sylvian fissure in lower part of motor cortex.	*Post-operatively:* R. hemiplegia much as before operation but aphasia more severe. Cyst retapped 4 mos. after operation, with slight improvement in her speech. Death occurred 4½ mos. after operation.	(Difficulty in speaking. Aphasic symptoms some help in diagnosis.)	Emotional. Aphasia of expressive type with very inadequate speech. Clear difficulty in evoking words. Receptive functions relatively well preserved. Noticeable perseveration.
II. Receptive Group									
44	34	R.	Meningeal fibroblastoma of L. parietal and occipital lobes.	1 year: 4 mos.: On admission:	Attacks of unconsciousness about every two weeks. Attacks occurring every week. Intention tremor both hands and weakness R. arm; generally hyperactive reflexes with suspicious Babinski on R. Irregular pupils, sluggish to light. R. homonymous hemianopsia. X-ray: thinning of the dorsum sellæ and posterior clinoid processes.	*First:* L. fronto-temporo-parietal craniotomy with plunge for localization of tumor lying in L. occipito-parieto-temporal region. *Second:* 3 months later; L. occipital craniotomy with removal of large encapsulated meningioma which arose from the angle between the falx and tentorium.	*Post-operatively:* Definite R. hemiparesis and more severe aphasia, both of which gradually improved until the condition 3 months after operation was about that before operation. *Post-operatively:* Death.	Slight aphasia of predominantly receptive type. Speech somewhat scanty and repetitious. Understanding slightly limited. Writing poorer than speech. Aphasic symptoms of some help in localization. Same as before first operation.	More limited speech, still well articulated. Much greater difficulty than before operation in repeating, understanding, reading and writing.
58	48	R. but has written with L. for 5 years.	Suspected tumor of slow growth in parietal and frontal lobes.	15 yrs.: 10 yrs.: On admission:	Occasional attacks numbness, beginning either in R. hand or face. Later: pain in supra-orbital region followed by headache. During attacks: drowsiness; inability to talk well and occasional diplopia. Weakness R. hand. Definite weakness R. face, tongue, palate and arm but little weakness of leg, and reflexes prompter on R. Touch, pain, temperature and vibratory sensibility normal in most examinations, but astereognosis occasionally apparent in R. hand. Definite ataxia of both upper and lower limbs on R. and muscle sense somewhat disturbed. R. palpebral fissure larger than L.; weakness in outward rotation R. eye; both cornea less sensitive than normal; secondary optic atrophy more marked on R. X-ray: sella turcica much enlarged with thinning of walls and marked encroachment on sphenoid sinuses.	Operation refused.	Unknown.	Personality changes over a period of 5 years reported by family. Slight aphasia of predominantly receptive type. Some confusion, hesitancy and faulty articulation in speaking. Understanding of more complex material, spoken or printed, poor. Apathetic and sometimes uncoöperative and suspicious. Aphasic symptoms aided in the diagnosis.	

TABLE I: (*Continued*)

No.	Age at First Hospital Admission	Handedness	Type and Location of Tumor	Symptoms before First Operation: Duration before 1st Operation	Symptoms before First Operation: Nature	Nature of Operation	Subsequent Course	Psychological Disturbances (Data taken from hospital records in parentheses): Pre-operative	Psychological Disturbances (Data taken from hospital records in parentheses): Post-operative
60	51	L. but trained to use R. for writing and sewing.	Adenocarcinoma of L. temporal lobe.	35 yrs.: 3 mos.: 2 wks.: On admission:	Severe migrainous headaches. Severe occipital headache, mostly on L. with frontal headache and tinnitus. Difficulty in vision. Vomiting spells. Distinctly ataxic gait with tendency to stagger to R. and L. Slight weakness lower R. face. Bilateral choked discs of about 2 D., more marked on L. with enlarged blind spots. Audiogram: 30 per cent. loss of hearing for speech in R. ear and 32 per cent. in L.	L. temporoparietal craniotomy, with removal of tumor lying in parietal region at a depth of about 5 cms.	*Post-operatively:* Slight R. hemiparesis and more severe aphasia, temporary improvement. Case of metastatic carcinoma but no evidence of primary lesion found. Death occurred about four months after operation.	For 3 mos. had noticed increasing difficulty in remembering names for persons and objects. Aphasia predominantly receptive but pre-operative picture not clear. Some difficulty in naming, but otherwise very little change in speech. Most marked difficulties in reading and writing. The aphasic symptoms were of distinct value and indicated the side of the operation.	Receptive aphasia more severe. Speech well articulated, but limited and somewhat confused. Naming greatly disturbed. Some difficulty in understanding spoken language which was not present before operation.
III. Expressive-Receptive Group									
2	32	L.	Subcortical glioma of L. temporal lobe.	2 yrs.:	Momentary complete loss of vision. Occasional dull frontal headache. Reflexes hyperactive but not pathological. Marked bilateral choked discs: 7 D. on R. and 8 on L. R. homonymous quadrantanopsia. X-ray: atrophy of dorsum sellæ and posterior clinoids.	Ventriculography followed by L. temporo-occipital craniotomy revealing large yellow soft area believed to be inoperable glioma.	*Post-operatively:* R. hemiparesis and severe aphasia, both of which persisted until his death 3¼ years after operation.	(For 2 years had noticed that reading slower and more difficult than before. Aphasia not definite.)	Severe aphasia affecting both expressive and receptive processes.
8	34	R.	Spongioblastoma multiforma of the L. frontal, temporal and parietal lobes. (Necropsy.)	1 mo.: On admission:	Speech difficulty; headache, nausea, vomiting and difficulty in vision. Weakness lower R. face and arm, with hyperactive biceps and triceps reflexes. Bilateral choking, more marked on L. Almost constant tasting and smacking movements of the lips and tongue. X-ray: slight calcification of pineal body.	*First:* exploratory craniotomy over L. temporal area with evacuation of gliomatous cyst. *Second:* 1 month later: evacuation of cyst with removal of portion of tumor.	*Post-operatively:* Satisfactory progress for 2 weeks when hemiparesis and more severe aphasia developed. *Post-operatively:* Condition unsatisfactory. Death occurred a week after operation.	(Speech difficulty of one month's duration. Mentally dulled on admission and disoriented for time and place. Aphasic symptoms were manifested first and aided in the diagnosis.) Increasing apathy and aphasia worse than immediately after the first operation.	Apathetic. Severe aphasia affecting both expressive and receptive processes. No speech response and no response to questions or directions.

IV. Amnesic Group.

7	35	R.	Astrocytoma of L. frontal, temporal and parietal lobes. (Necropsy.)	11 yrs.: 7 yrs.: 2 yrs.: 1 yr.: On admission: On readmission, 1 yr. 2 mos. later:	Jacksonian convulsions of tongue and R. side face and arm, and more rarely whole R. side. Numbness of R. arm. Difficulty in vision, particularly after a convulsion. Difficulty in speech, at first only after convulsion. Some loss of power R. limbs. Increasingly frequent convulsions. Headache, pain in R. arm and aphasia. Weakness lower R. face; R. knee and Achilles reflexes exaggerated. Marked sensory disturbances of whole R. side. R. upper limb ataxic and astereognosis in R. hand. Pupils irregular and slightly sluggish to light; some nystagmus on extreme rotation. R. homonymous lower quadrantanopsia. X-ray: marked calcification of vessels on L. in motor parietotemporal area about the region of the optic thalamus. Weakness of R. face, arm and leg with usual increase of reflexes and Babinski. Marked sensory disturbances on R.	L. fronto-temporo-parietal craniotomy with partial removal of an infiltrating glioma which had invaded the pre- and post-central gyri and the parietal lobe and extended inwards and possibly implicated the thalamus.	*Post-operatively:* Complete R. hemiparesis and more severe aphasia. Power on R. gradually returned until he was in much the same condition neurologically as before operation. Sensory Jacksonian attacks lessened for a time but after about 2 months all symptoms became increasingly marked. Death occurred 10 months after operation.	Marked difficulty in evoking words as names from time of first examination 1 yr., two mos. before operation. Central amnesic difficulty apparent in many language processes. Aphasic symptoms first present 4 yrs. after beginning of symptoms and in conjunction with other signs were of aid in the diagnosis. Patients studied intensively both before and after operation.	More severe aphasia than before operation but still of amnesic type. Slight improvement during first two months followed by marked deterioration. No further change during the last months of his life.
17	36	R.	Spongioblastoma of L. temporal lobe.	2 mos.: 5 wks.: On admission:	Convulsion lasting 20 min. with unconsciousness; no recurrence. Difficulty in vision; difficulty in finding words; headache, nausea, vomiting, dizziness, tinnitus L. ear. Uncertain gait with tendency to fall to L. R. homonymous hemianopsia. Bilateral choking of about 2½ D.	L. frontotemporal craniotomy with exposure of tumor lying in temporal lobe posterior to Rolandic fissure.	*Post-operatively:* R. hemiparesis which improved slightly for a few months, and more severe aphasia. Death occurred 6 months after operation.	Marked aphasia of amnesic type. Patient studied both before and after operation. Aphasic symptoms of distinct aid in establishing side of lesion.	Aphasia more severe, with speech performances so limited that type was no longer clear. No improvement and is reported not to have talked at all during last 2 months of life.
18	32	R.	Gliomatous cyst of L. temporo-parietal area; astrocytoma.	7 yrs.: 4 yrs.: 2 mos.: 1 mo.: On admission:	Generalized convulsion beginning in R. hand and face with unconsciousness, following birth of first child. A second attack 3 wks. later. About the same time began to have chattering spells of jaw, trembling of R. hand and biting of tongue. Six other major seizures preceding and following birth of second child. Another major seizure. Diplopia. Increased intracranial pressure; bilateral choking of about 3 D. on each side; enlarged blind spots.	Exploratory operation over L. temporoparietal area which did not reveal a lesion.	*Post-operatively:* Severe aphasia and several generalized convulsions. Chattering spells persisted, and a few major convulsions. 12 months after operation bumped her head on getting into a car and afterwards had several attacks of paralysis of R. arm and leg with numbness and a senseless sort of speech. Examination revealed marked weakness R. face, arm and leg with increased reflexes and a Babinski and paræsthesias in upper and lower extremities.	(No changes reported prior to admission or before first operation.)	(Severe "motor" aphasia which cleared up in about 3 months, but returned about 14 months after operation.)

TABLE I: (*Concluded*)

No.	Age at First Hospital Admission	Handedness	Type and Location of Tumor	Symptoms before First Operation		Nature of Operation	Subsequent Course	Psychological Disturbances (Data taken from hospital records in parentheses)	
				Duration before 1st Operation	Nature			Pre-operative	Post-operative
						Second: 14 months later: Evacuation of large temporoparietal gliomatous cyst with removal of part of tumor.	*Post-operatively:* Paresis and speech disturbances gradually improved, but chattering spells persisted and in about 6 months became more frequent. Cyst punctured several times during next two months with temporary improvement in speech and motor power.	(Marked aphasia.)	(Aphasia improved but in about 6 months patient complained of apathy and loss of memory.) Examinations made during admission when cyst was punctured revealed aphasia of amnesic type. Considerable emotionality.
						Third: 10 months after second: Evacuation of gliomatous cyst and large mass of tumor removed from L. frontal area.	*Post-operatively:* Condition about the same: R. hemiparesis, headaches and aphasia. Cyst again tapped a year later without much change in condition. 3 months later reported progressively worse.	Severe aphasia.	(Severe aphasia.)
42	13	R.	Abscess of L. central and parietal areas.	1 mo.: On admission:	First of attacks of severe headache; others, accompanied by vomiting and drowsiness followed. Sudden attack of Cheyne-Stokes respiration. Spinal fluid examinations showed increased cell count but no definite bacteriological findings. Dullness, apathy and headache: stiff neck and positive Kernig's sign. Complete paralysis lower R. face and arm; slight of leg; increased reflexes but no Babinski. Slight ptosis of L. lid; paralysis of R. 6th nerve; definite bilateral choking, more marked on R.	First operation one month after admission and a series of operations after this, showing large abscess in L. central and parietal areas.	*Post-operatively:* Greater paresis on R. and R. homonymous hemianopsia. Aphasia developed 3 months after onset. Some improvement in motor power; R. homonymous hemianopsia persisted; papilloedema decreased, leaving secondary optic atrophy.	(Dulled, apathetic. Aphasia did not develop until 2 mos. after 1st operation.)	Examination 2 months after aphasia had developed showed severe amnesic aphasia.
47	12	R.	Abscess of L. temporal lobe.	Several yrs.: 2 wks.: On admission:	History of running L. ear. Drowsiness; difficulty in speaking; photophobia; pain in eyes. Slight weakness lower R. face; hyperactive reflexes on R. with Babinski; slow pulse; slight leucocytosis. Concentrically contracted fields.	Two-stage operation over L. mastoid area, revealing a discharging sinus leading for 2 inches into the brain tissue; drainage.	*Post-operatively:* Condition improved very rapidly and patient was apparently entirely normal on discharge 5 weeks after operation.	Aphasia of amnesic type in conjunction with other symptoms was of distinct help in localizing side of lesion.	Aphasia decreased after the first stage of the operation and cleared up very rapidly after final stage.

that aphasia has frequently been diagnosed where none exists or that the type of speech disturbances has been wrongly diagnosed—as in nineteen of the cases examined—with the additional disadvantage of a suggested cerebral localization where none is really possible.

A summary of the important facts on the type of pathology, the onset of the symptoms and their nature, the operative findings and the post-operative course is presented for the fifteen tumor cases in Table I.

Of the five *expressive* cases, there were distinct aphasic symptoms prior to operation in only two; in neither was the speech disturbance a decisive factor in establishing a diagnosis. In one of these cases, No. 34, in which the aphasic symptoms were more distinct, the diagnosis (calcified tumor of the mesencephalon) was established by means of the X-ray. In all of these cases speech disturbances should have been present if the old ideas of localization are accepted.

In the three *receptive* cases the aphasic symptoms were of distinct value and aided in the diagnosis, and at least in one case, No. 60, in the absence of more decisive symptoms, indicated the side of the operation. It is interesting that this patient was left-handed but had been trained to use the right for writing and sewing. The lesion was an adeno-carcinoma of the left temporal lobe but the most marked disturbance before operation was not in speaking or understanding but in reading and writing. In one of the three cases, No. 58, no operation was permitted; in the other, two examinations were made both before and after operation. In each instance the first examination showed aphasia of the receptive type. Post-operatively, with the exception that the aphasia was more marked, there was little change.

Of the two *expressive-receptive* aphasics, in the first, No. 2, the speech difficulty was not clear-cut before operation, but the reading pace was slower and long words had to be spelled out before they were understood. This was another left-handed patient with a lesion in the left hemisphere. In the second case the aphasic symptoms appeared first and were of distinct help in the diagnosis, although subsequent neurological symptoms indicated the site of the lesion.

The five *amnesic* cases were most interesting because it was only in these tumor cases that this distinctive type of aphasia was found. In three, examinations were made both before and after operation, and in one, No. 7, the aphasia was studied for over a year before operation. In two cases an abscess was found; in the first, No. 42, of rather large size in the left central and parietal areas and in the second, No. 47, in the temporal area only. Of the other three cases, in one, No. 7, in which a necropsy was obtained, a large calcified astrocytoma occupied about two-thirds of the left hemisphere. In the others, operation revealed a spongioblastoma in the left temporal lobe, No. 17, and an astrocytoma of large size, No. 18, in the temporoparietal area.

Why these lesions of varying size and character should have developed amnesic aphasia we are at a loss to explain. It is not because of the type of the lesion nor the size, for as pointed out previously, in three the lesion

was of a gliomatous character and in two abscess formation. In at least two, Nos. 42 and 47, the lesions were limited in size. Nor is the period of the symptomatology of any aid, for while in case No. 7 the symptoms were eleven years in duration, in cases Nos. 17 and 42 they were only a few months.

From the localization standpoint, in three cases the aphasia developed after the operation; in two there were alterations of personality and other vague symptoms, but no definite aphasia was reported until after operation; in the remaining ten, aphasia was present before operation. Of these ten the aphasic symptoms were of help in conjunction with others in establishing the side of the lesion in cases Nos. 34, 59, 44, 58, 2, 8 and 7 and because of the paucity of the other symptoms they were of particular assistance in cases Nos. 60, 17 and 47.

PSYCHOLOGICAL CHARACTERISTICS.—When the psychological characteristics of the tumor cases as a group are compared with those of the vascular or traumatic groups, certain differences become apparent. The tumor cases are on the whole slightly more variable, and with the exception of the amnesic patients they show a less clear-cut disorder. These two differences are sufficiently marked to warrant attention, but it must be noted that they are not characteristic of the individual tumor case as opposed to the individual vascular or traumatic case. There are wide differences within the tumor group as well as within the vascular or traumatic, so that some tumor cases, for example, are actually less variable or show less complicated disorders than individual vascular cases.

With regard first to the question of variability, it must be noted that all aphasic patients are likely to vary in their success with single test items. They name an object correctly one day, for instance, and fail to name it the next. But a better criterion of variability than this response to single items is the average performance on a number of items. Judged on the basis of average performance, vascular and most traumatic cases may improve steadily or regress, but they do show appreciable daily fluctuations. Tumor cases are more likely to show such fluctuations, although even here the difference between the performances on one day and on the next is not great. Large fluctuations, however, do appear in few tumor cases and may be related directly to the acute lesion and the rapid changes in pathology.

In some cases, generally either shortly pre- or post-operative, the condition is so acute that the patients cannot be examined in any systematic way and so individually are of little value in a study like this. In fact, no such patients were included in this group unless more satisfactory examinations could be made when the general condition was better. In the acute stages responses are not only difficult to elicit but extremely irregular. The irregularity, however, is certainly not characteristic of the language responses alone, but of all reactions. It is the result of the disturbed condition of the whole organism, and specifically of the rapid pressure and œdematous changes in the brain. Considered from the practical rather than the research point of view, it must be noted that test results may be valuable even in this condi-

tion, but only for their positive findings. In other words, the results are important in so far as they show what the patient can do, but the negative results do not establish limits of ability and are significant only as gross indices of the relative difficulty in different kinds of performance.

The second group of cases which may show a large amount of variability in performance is also characterized by great changes in the pathology. These patients may be regular and consistent in their performances on any one day but they may have changed considerably by the next day if there has been an increase or decrease in pressure. An excellent example is No. 18 whose performances varied according to the condition of the fronto-temporo-parietal cyst and improved after it had been tapped.

The differentiation between the tumor and the vascular or traumatic cases on the basis of the clear-cut or complicated disorder really affects only a part of the tumor group. It has already been noted that the amnesic disorder, which appeared among these patients only in tumor cases, is relatively clear-cut and that the changes depend almost entirely on difficulty in evoking words as names. With regard to the expressive-receptive patients where the disorder is by definition one which affects all language processes, there is of course no question of a clear-cut disorder. The matter affects only the expressive and receptive patients then, and of these it may be said that while the distinction between predominantly expressive and predominantly receptive can be made for the tumor cases, it is less satisfactory than for the vascular or traumatic cases. The tumor patients of the predominantly expressive type are likely to show changes more characteristic of the predominantly receptive disorder and *vice versa.* For instance, the expressive patients, in addition to their typical errors in articulation and word formation, are likely to have difficulty in evoking words and to produce verbal and grammatical confusions. Interestingly enough, all the patients chosen to illustrate the expressive or receptive disorders were vascular or traumatic in origin. The failure to choose tumor cases was unintentional, and in part fortuitous; since few tumor cases could be examined for long periods, their records are less complete and decisive. In part, however, it resulted from the fact that few of the expressive or receptive tumor cases were so clear-cut as those from other types of pathology.

SUMMARY.—In ten of the fifteen tumor or abscess cases aphasic symptoms were present before operation, and in two others there were alterations in personality with other vague symptoms which on closer analysis might have been shown to be aphasic, while in the remaining three the speech disturbances developed after operation. In practically all cases the aphasic symptoms were of help in localization, and in three because of their early appearance and the paucity of other symptomatology, the speech disturbances were of distinct value, but only in determining the side of the brain in which the lesion was located. By no means was there any evidence of a stricter localization.

The tumor cases as a group differed from the vascular in two charac-

teristics: they were more variable and with the exception of the amnesic patients they showed less clear-cut disorders. The greater variability is undoubtedly to be related to the acute lesions and the rapid changes in pathology. The fact that the expressive and receptive disorders were more complicated in the tumor than in the vascular cases, and consequently that the tumor case was more difficult to classify as either predominantly expressive or predominantly receptive, must depend on the larger area affected in the tumor cases, but without a complete destruction, that is, with certain intact axis cylinders still remaining.

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PATHOLOGY OF ACUTE PURULENT MENINGITIS

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Acute purulent meningitis is relatively frequent. Its types and clinical course are well known. Therapeutic serum has been developed for the group due to the meningococcus. Aside from this epidemic form the mortality rate is close to 100 per cent. Autopsy studies are frequent. The gross appearance of the brain and cord of acute purulent meningitis is characteristic. Yet with all this, there are many problems in purulent meningitis that are still unsolved.

One of the first things of interest from the pathological angle is the gross appearance of the brain in different forms of meningitis. As a general rule, a brain from a case of acute purulent meningitis shows an exudate over both cerebral hemispheres in the subarachnoid space. It is recognized that when a purulent meningitis is secondary to a nasal sinus or mastoid infection, the purulent material is greatest at the base of the brain, and usually in direct relation to the original focus. Recently two cases have come to autopsy in which only the hemisphere in relation to the infected mastoid was involved by a meningeal infiltration. In tuberculous meningitis, in contrast to the usual acute purulent forms, the common finding is a gelatinous exudate, for the most part concentrated in the interpeduncular space, from which point it spreads out in all directions.

Types of Acute Purulent Meningitis.—For descriptive purposes we can divide acute meningitis into three groups—(1) Early and rapidly fatal cases in which frequent spinal or cisternal drainages had not been performed. (2) Subacute and chronic forms including particularly the meningococcic form in which serum therapy had been given. (3) Cured cases.

Group (1).—Under the first heading of early and rapidly fatal cases, Case I is a good example of a large series of similar cases.

Case I.—A fifty-six-year-old white male was admitted to the Temple University Hospital, February 21, 1930, and died February 23, 1930. He was admitted in stupor. He had been sick but a few days. There were ptosis of the left eyelid, horizontal nystagmus, coarse tremor of the hands and a rigid neck. The temperature was 100° F. A lumbar puncture revealed a cloudy fluid with 1,250 cells, all of which were polymorphonuclears. The diplococcus intracellularis was found. The sinuses were negative.

Post-mortem examination revealed a thick purulent exudate covering the hemispheres, pons, and posterior portion of the cerebellum. The convolutions were flattened and the sulci and ventricles were filled with pus.

On microscopical study it was found that almost uniformly over the entire brain

the subarachnoid spaces were completely filled and over-distended by a cellular exudate (Fig. 1). This exudate was made up almost entirely of polymorphonuclear leucocytes and formed a dense mantle over the entire brain and dipped down to the bottom of every sulcus. The blood-vessels were dilated and engorged. In the smaller blood-vessels there was noted a swelling of the lining cells and in places could be seen a beginning separation of the elements of the media with serous outpouring and beginning hyalinization. Here and there, throughout the entire meningeal space, it was found that the polymorphonuclears were disintegrating and forming pus. Occasionally could be seen penetration of the exudate into the adjacent cerebral tissue. This penetration many times spread out from the perivascular space of a blood-vessel, but already degenerative changes in the sector involved could be seen, mainly in the form of a severe ischæmia. With the changes in the spinal fluid spaces belong also those which occurred in the ventricle. The same type of exudate was seen over the ependyma as over the cortex, with a severe subependymal reaction.

The cortex itself gave evidence of a most profound change. In the first place practically every ganglion cell showed a degenerative process of the ischæmic type.

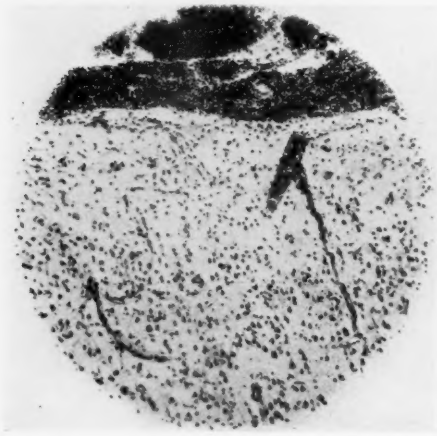

FIG. 1.

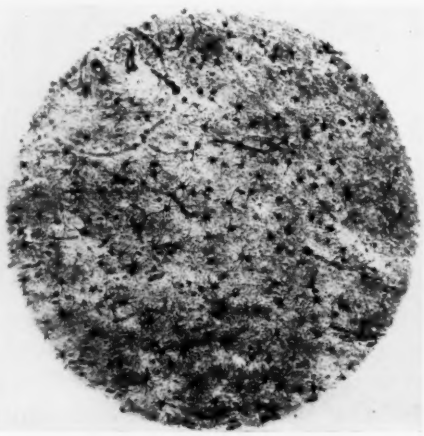

FIG. 2.

FIG. 1.—(Case I).—Marked meningeal infiltration of polymorphonuclear cells, with perivascular cuffing of one adjacent vessel. Cortex shows marginal gliosis and beginning vascularization. Prominence of small vessels is a feature. With magnifying glass one can make out ischæmic changes in many of the ganglion cells.

FIG. 2.—(Case I).—Cajal stain showing marked macroglial increase in cortex.

Many of the ganglion cells were missing and shadows could be seen of their former structure (Schattenzellen) and vacant spaces. Those remaining gave evidence of mild swelling, loss of Nissl granules and a tendency to granular staining of the cytoplasm, pyknosis of the nucleus, and with the Unna-Pappenheim stain the cytoplasm took up the red color with too great avidity. The blood-vessels, especially the smaller ones, stood out and were out of proportion to the rest of the cortical elements. The blood-vessels that were cut longitudinally could be traced for quite a distance because of the swelling and dark staining of their lining cells. At times there was such reduplication of the cellular elements of the wall that at first glance it resembled a perivascular infiltration. Vessel budding was by no means uncommon. Around most of the vessels could be seen a marked dilatation of the spaces of His, as evidence of the intense œdema. The glia was proliferated out of proportion to the rest of the cellular elements. With the Cajal stain for macroglia (Fig. 2), an increase was seen which rivaled that of dementia paralytica. Particular mention must be made of the marginal layer which in many places was so densely packed with glia cells that one could hardly distinguish the demarcation between the first and second cortical layers. In the marginal

layer it at times could be seen that the blood supply was even insufficient for the glia, and clasmatodendrosis resulted. Only occasionally was there to be seen a perivascular infiltration of some of the small vessels at the cortical margins (Fig. 1), but as a rule this did not extend for any distance except when devitalization of the cortex had already occurred. In the subcortex also could be seen a severe proliferation of glia, mainly of the macroglia type with small areas of disintegration throughout. Occasionally in the subcortex small areas were seen in which polymorphonuclear cells were accumulated, usually around a blood-vessel, and there were often perivascular accumulations of polymorphonuclear cells with severe œdema. The medium-sized vessels in the brain were already beginning to show hyalinization of walls similar to that seen in the meninges. It was thus possible in this case to trace the changes in the small and medium-sized blood-vessels from the beginning.

COMMENT.—Here the reaction in the meninges is entirely polymorphonuclear, the brain œdema is intense, the small vessels show a marked swelling of their lining cells, and general gliosis is as marked as one sees in dementia paralytica, with clasmatodendrosis as evidence of the intense anoxæmia which had developed. These are usually the cases which have not been sufficiently drained spinally or dehydrated. One often sees an intensely swollen brain, the result of cerebral œdema, as in tuberculous meningitis, brain trauma, or even brain tumor, where the amount of cerebrospinal fluid may be less than normal. This is the type of case where spinal drainage avails little in reducing the intracranial pressure, and relief can be obtained only by intravenous hypertonic solutions (Kubie[1]).

In cases of acute meningitis a vicious cycle may be produced. The more intense the meningeal inflammation, the greater the intraspinal pressure and the less the blood supply to the brain. This can result from pressure on the incoming vessels and on the outgoing vessels as well, and more often on the latter than the former, because of greater compressibility. One often, therefore, sees at post-mortem a cyanotic brain as the result. The greater the anoxæmia, the greater the transudation of fluid into the tissues (Landis[2]) and the more severe the resulting intracranial pressure, thus helping to further increase the intracerebral œdema. In the absence of spinal drainage and brain dehydration, stupor increases and death results.

GROUP (2).—In the subacute form of acute meningitis Case II is an example taken from a series of similar cases.

CASE II.—A white male of twenty-five years was admitted to the Temple University Hospital December 27, 1930, and died January 9, 1931. December 14 he became ill with cough, sore throat, and expectoration. Two days before admission a severe headache set in followed by chills, nausea, fever, vomiting, and rigidity of the neck. In the hospital it was found that he had 18,300 white cells in the blood, of which 86 per cent. were polymorphonuclears. The spinal fluid was milky and contained 4,000 cells per cubic millimetre. The diplococcus intracellularis was found. He was given specific serum intravenously and intraspinally, but did not improve and died.

Post-mortem examination revealed a brain weighing 1,450 grams. There was a purulent, greenish exudate, particularly at the base. There was a secondary obstructive internal hydrocephalus. The cortex was congested. The ventricles were dilated and contained a slight amount of pus.

Microscopically the subarachnoid space was definitely distended as the result of a

cellular exudate plus a moderate œdema and fibroblastic proliferation. The cellular exudate was made up mainly of lymphocytes and phagocytic cells of the reticulo-endothelial system (macrophages) and to a much less degree of plasma and polymorphonuclear cells. As a rule the polymorphonuclear cells had to be diligently sought for and even plasma cells were more numerous. A moderate increase in fibroblasts was a fairly uniform finding.

As far as the cortex itself was concerned, several findings immediately stood out: in the first place there was a moderately severe marginal gliosis as part of a generalized glial increase of the entire cortex. Second, there was a marked decrease of ganglion cells, with various degenerative changes in those remaining, especially ischæmia and sclerosis. Third, the smallest blood-vessels stood out more prominently than normal because of swelling and proliferation of their lining cells, while the larger vessels showed swelling and hyalinization of walls. Fourth, by careful search could be found small verödungsherde, but they were not frequent. Occasionally a change such as is pictured in Fig. 3 was seen where the upper cortical layers are involved by a focal area in which complete loss of ganglionic elements had occurred. In these areas repair

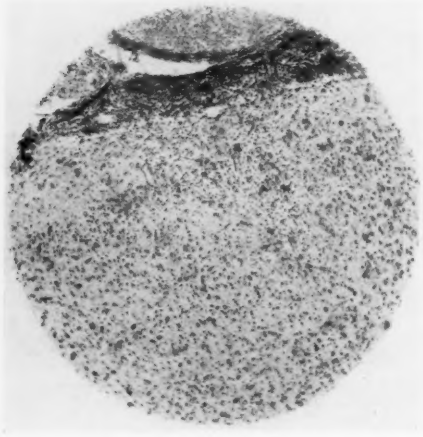

FIG. 3.

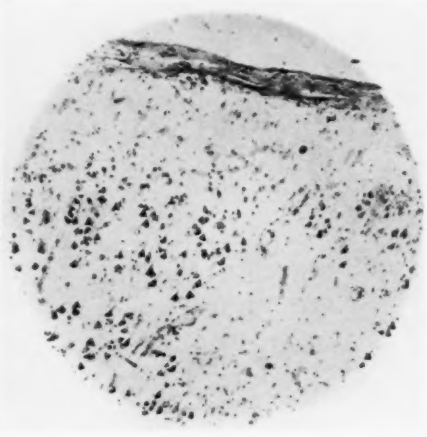

FIG. 4.

FIG. 3.—(Case II).—Subacute meningitis with lymphocytic cells in subarachnoid space. Small focus of cortical degeneration extending donward in "V" shape with gliosis and beginning vascularization, without penetration of meningeal exudate.
FIG. 4.—(Case III).—Cerebral cortex showing mild meningeal fibrosis, general glia increase and large area of verödungsherde in second and upper third cortical layers.

was in progress as shown by the advancing vascularization and gliosis. Here it can be seen that the membranes are fibrosed and still contain inflammatory elements mainly of the lymphocytic type.

As part of the cortex, Ammon's horn deserves special mention. Surrounding this part of the brain the meningeal infiltration was much more marked than over the vertex, an occasional adjacent vessel was perivascularly collared with the same types of cells present in the meninges. Sommer's sector was also the vulnerable area and showed a marked loss of cells, with many of those remaining being shadow cells.

In the subcortex evidences of a previous degeneration and œdema were found. Here the vessels, some of which had a granular appearance, were surrounded by lakes of fluid. There were in many of the adventitial spaces pigment-containing phagocytic cells. The choroid plexus for the most part was entirely normal.

GROUP (3).—In the following case we have had the unusual opportunity to study the brain of a patient who made a recovery from a meningococcic meningitis only to die from trauma.

CASE III.*—A white girl of ten entered the hospital with the history of being well until two days before admission, when she became ill with signs and symptoms of an acute meningitis. Treatment effected a complete cure in two weeks. Within four weeks she met with an accident which caused her death in twenty-four hours.

Gross examination of the brain showed a rather marked congestion of the brain substance and meninges, but there was no evidence of the former meningeal condition, except for a mild pressure cone around the cerebellum and medulla, probably the result of the numerous spinal punctures. On section no gross abnormalities could be determined. The ventricles were of normal size and the choroid plexus was normal.

Microscopically the entire pia-arachnoid was almost entirely devoid of all inflammatory elements. Only occasionally could there be found small numbers of polymorphonuclear cells around some of the larger blood-vessels. There was in places a mild œdema with at times phagocytic cells, some of which still contained débris. A general increase in the amount of connective tissue was a universal feature, but it was by no means marked.

The most dramatic finding was the presence of acellular areas (verödungsherde) of various sizes, for the most part, however, small and mainly perivascular. Fig. 4 illustrates one of the larger acellular areas of this sort. This shows clearly the complete loss of ganglion cells in a sharply defined area, the absence of all reactive manifestations on the part of the surrounding tissue and the absence of reparative changes within the focus. This was but one of many such foci scattered irregularly throughout the cortex, but they were by no means as large as the one pictured here.

The medium-sized cortical and subcortical vessels had moderately thickened walls that were hyalinized. Many of them had evidences of perivascular œdema in the form of spaces of His around most of these vessels. At times pigment-laden phagocytic cells could be found in the Virchow-Robin spaces.

DISCUSSION

Acute purulent meningitis is an acute inflammation of the leptomeninges, provoked by a variety of organisms, the most common of which are the meningococcus, pneumonococcus, and streptococcus. There is a preliminary blood-stream infection in many cases and the meningeal involvement is secondary. Cases have been reported and we ourselves have studied similar cases in which the infection in the blood-stream produced death prior to the development of a frank meningitis. By what path the organisms reach the subarachnoid spaces is not entirely clear. At times there results in the brain multiple abscesses (Oppenheim[5]) with secondary infection of the meninges and at other times meningitis occurs without the presence of pyæmic abscesses (Untersteiner[6]).

The involvement of the meninges can occur as the result of extension from a neighboring infected area (Eagleton[7]). This is seen most commonly in mastoid disease where involvement of the meninges is most pronounced in relation to this infected focus. It is not very difficult to explain cases of this sort.

After the organisms have reached the subarachnoid space, there occurs an inflammatory reaction which differs in no way from inflammations elsewhere

*A very similar case has been studied, through the courtesy of Dr. Truman Schnabel, from his service at the Philadelphia General Hospital, with very similar findings.

in the body. There occur congestion, œdema and exudation, the intensity of which depends not only on the virulence of the organisms, but on the defenses of the tissue. Depending on these two factors the cases have been divided in this paper into three great groups. The first includes those in which the inflammatory process was so intense that death occurred within a few days with or without treatment. The second group included those cases where as the result of treatment or some inherent defense of the patient the process was much slower and a subacute condition resulted. The third group includes those that recovered from the meningeal infection with only residual phenomena.

The histopathology that one sees in the first group is that of an intense inflammatory reaction with œdema, congestion, and even hæmorrhage; and with a reaction on the part of the brain including congestion of all the blood-vessels, œdema, and a reactive gliosis, especially of the marginal layer. Very frequently, we have also a prominence of the small blood-vessels as the result of swelling of their lining cells. As a rule a marked anoxæmia of the brain is present which is frequently mirrored in the ganglion cells as the result of which they show a type of change that has been called ischæmic cell disease. Wertham,[8] Hassin[3] and Wohlwill[9] mention somewhat similar changes.

In the second group, where the disease has been more prolonged, certain changes in the histological picture have taken place. The most striking one has been an alteration in the infiltrating elements. While in the first group there were practically entirely polymorphonuclear leucocytes, we find in the second group an admixture with lymphocytes and even plasma cells and at the same time numerous macrophages are thrown out, many of which contain débris of various sorts. A beginning fibrosis of the meninges is evident. As the disease becomes prolonged, the chronic elements gradually become more and more prominent until finally a case of this sort can be mistaken for one due to the tubercle bacillus or even to the spirochæte. One does not find, however, the panarteritis tuberculosa or the Heubner endarteritis; on the contrary the blood-vessel changes are similar to those found in any chronic infection or intoxication of the nervous system.

As far as the brain itself is concerned, one finds two general types of changes as the result of the intense œdema and consequent interference of its blood supply. The generalized cloudy swelling of the ganglion cells, which occurs from any toxæmia, gradually gives way to an ischæmic cell process characteristic of severe interference with the blood supply. The congestion and œdema of the entire brain is but part and parcel of the inflammatory process in the meninges. The second change which one finds in the cortex is the result of penetration of the inflammatory exudate into adjacent brain tissue. One very frequently sees coagulation of the tissue prior to its invasion by the inflammatory process.

One finding in the brain deserves more than passing mention. In cases of this sort we have found a marked general overgrowth by astrocytic cells comparable in every way to that which occurs in dementia paralytica. This

gliosis can disappear when there is improvement and the patient makes a clinical recovery similar to the disappearance of the glia cells during the remission of dementia paralytica.

In the third group we have had the opportunity of studying an extremely interesting and unusual patient in whom a complete recovery from meningitis occurred, with death a few weeks later from trauma. In this case there had occurred complete disappearance of the meningeal inflammation with only occasional clumps of phagocytic cells in the subarachnoid space. A mild fibrosis bore evidence of the previous irritation. The blood-vessels showed hyalinization of their walls, but the swelling of the lining cells of the smaller vessels had practically entirely disappeared. The general picture of the ganglion cells was noticeably improved, but one found scattered throughout small areas of loss of ganglion cells (verödungsherde) which usually are interpreted as the result of vascular occlusion. It might be stated also that no such areas were found in Sommer's sector, which is considered by the Spielmeyer School[4] to be one of the most vulnerable areas of the brain as far as its involvement of vascular occlusion is concerned. These acellular areas in our patient differed in no way from those due to any other toxic or infectious process and were so few in number that they had to be sought for very carefully. The question of residual symptoms from areas of this type, from the clinical angle, might be answered by stating that probably all infections and intoxications leave behind evidences of this sort in the brain, but only rarely are clinical evidences of these foci present. Unless areas of this nature are extremely numerous, one will not get clinical evidence of their presence.

SUMMARY AND CONCLUSIONS

(1) The histopathology of acute purulent meningitis has been investigated from a study of three different types of cases.

(2) The first type of case is the very malignant form of meningitis, with death in a few days, in which there is an intense meningeal infiltration with polymorphonuclear cells, œdema, congestion, and hæmorrhage, as well as reaction on the part of the brain substance of a rather intense nature.

(3) In the second group, where the process has lasted a longer time, evidences of chronicity appear, such as the pouring out of lymphocytes and plasma cells and beginning fibrosis of the membranes. The reaction within the brain itself in this group is much more pronounced.

(4) The third group represents a case where the patient had made a recovery from acute meningitis and the residuals are shown by mild fibrosis in the meninges and acellular areas and secondary vascular changes in the brain.

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Part Two

GENERAL SURGERY AND ALLIED SUBJECTS

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OBSERVATIONS ON TOTAL PULMONARY LOBECTOMY AND PNEUMONECTOMY

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During the last year or two much interest has been aroused by the increasingly frequent and successful surgical removal of a lobe of the human lung, or even of an entire lung. The technic of total pulmonary lobectomy has made such rapid advances in recent years that the mortality has been reduced to less than 15 per cent. in several clinics. Until three years ago no patient had survived the period of surgical convalescence following total pneumonectomy; since then seventeen patients have survived.

Much experimental work during the last twenty years demonstrated the feasibility of lobectomy and pneumonectomy in animals. Application of the same technics to man resulted, however, in such a prohibitive mortality that they were virtually abandoned in clinical practice. The persistence of Archibald, Biondi, Brunn, Churchill, Evarts Graham, Janes, Kuemmell, Lilienthal, Willy Meyer, Samuel Robinson, Sauerbruch, Shenstone, Whittemore and Zaaijer, among others, who applied themselves to the problems peculiar to man, is chiefly responsible for the many recent successful operations. Scarcely five years ago it seemed unlikely that total lobectomy and total pneumonectomy would ever become sufficiently safe to be acceptable in clinical practice.

LOBECTOMY

There is still a division of opinion among surgeons as to whether a one-stage or a two-stage operation is the better. From the point of view of the patient's convenience and comfort an operation that is completed at once, and that may not be even temporarily followed by a bronchopleural fistula, is obviously preferable to a two-stage procedure. The choice of an operation of the magnitude of a total lobectomy must, however, be made largely according to the factor of safety.

The one-stage lobectomy operation that has produced the best results is that which has been developed by Brunn, Shenstone and Janes from the principles that were established by Garrè and Quincke, and by Lilienthal during their pioneering work. Brunn has reported two deaths (25 per cent.) out of eight patients and Shenstone and Janes eight deaths (29.6 per cent.) among twenty-seven patients. Tudor Edwards lost seven (14.5 per cent.) of his forty-eight patients and Roberts and Nelson two (20 per cent.) of ten patients. Churchill has had one death (11.1 per cent.) among nine one-stage lobectomies. Archibald has reported three deaths (23 per cent.) among

thirteen patients. The mortality figures given in this paragraph, which total twenty-three deaths (20 per cent.) out of one hundred and fifteen patients, are the most favorable ones known to me for the one-stage operation.

The success of the modern lobectomy operation in two or more stages is based upon the production of firm pleural adhesions over the lobe that is not to be resected. The largest series is that of Sauerbruch and Nissen; there were six deaths (12.7 per cent.) among forty-seven patients. Nine patients among the forty-seven had a "piece-by-piece" lobectomy; two died. Only four (10.5 per cent.) of the thirty-eight who had other types of multiple-stage operations died. My associates, Cameron Haight, John C. Jones, Duane Carr, and I have used a two or more stage total lobectomy for twenty-five patients, five of whom died (20 per cent.). Two of these five deaths occurred in patients with extensive bilateral bronchiectasis; one patient died from atelectasis of the right lower lobe two weeks after removal of the right middle lobe, the left lower and left "middle" lobes having been removed several months previously; the other patient died from progressive cavitation in both lungs about two months after removal of the right lower and middle lobes; the eventual removal of the left lower and left "middle" lobes had been contemplated. By excluding these two fatal cases of extensive bilateral bronchiectasis, we have used the type of two-stage operation that I am convinced offers the greatest protection against the dangers that are inherent in lobectomy in our last twelve patients, of whom only one died (8.3 per cent.). Churchill has performed ten two-stage lobectomies for bronchiectasis; one patient died (10 per cent.). There were twelve deaths (14.6 per cent.) out of the eighty-two patients included in these three series of two-stage operations.

The deaths reported in the various one-stage and two-stage series here quoted were not all immediately directly due to the operation; occasionally death was due to some such complication as pneumonia, cerebral abscess or activation of a latent tuberculous pulmonary lesion.

ONE-STAGE LOBECTOMY

Briefly, the type of one-stage lobectomy operation that is now in use consists of a long intercostal incision, lineal division of the posterior ends of two or three ribs, temporary occlusion of the hilum of the diseased lobe by a special tourniquet, resection of the lobe, oversewing of the hilar stump, removal of the tourniquet, suture of the stump against the interlobar surface of the remaining lobe, introduction of an air-tight intercostal drainage tube into the pleural cavity and complete closure of the intercostal incision. The technical details are given in articles by Brunn, Shenstone and Janes, Janes, and by Roberts and Nelson. Probably a majority of the patients operated upon by the modern one-stage technic do not develop a bronchopleural fistula or, if one develops, it closes spontaneously within one or two weeks. The air-tight drainage tube causes the remaining lobe to expand rapidly; the pleural space left by removal of the pulmonary lobe becomes rapidly reduced in size by virtue of expansion of the remaining lobe, elevation of the para-

lyzed diaphragm and traction displacement of the mediastinum. Only a minority of the patients who have had a basal lobectomy require an open drainage operation for the residual empyema.

In spite of the highly satisfactory operative and post-operative course of those patients whose one-stage lobectomies have been accomplished without operative accident or post-operative complication, fatal or grave complications are not rare. The most dangerous complications are severe infection of the entire pleural cavity before the undiseased lobe has become adherent to the parietal pleura, operative or post-operative hæmorrhage from the hilar stump of the resected lobe, sudden tension pneumothorax due to opening of a hilar bronchus in the presence of an accidentally occluded drainage tube, and pneumonia or an exacerbation of infective pulmonary lesions that may have been present in the contralateral lung before operation. Although post-operative pneumonic complications are not restricted to patients who have had one-stage operations, I believe that the relatively prolonged time required for a one-stage operation in the presence of a wide-open pleural cavity exposes the patient to a greater danger of pneumonia than if each operation were quickly completed, as it ordinarily is in the two-stage procedure.

Generalized infection of the pleural cavity does not often occur after the one-stage operation in spite of the fact that the pleura becomes at least slightly soiled when the surgeon divides the pus-containing bronchi in the hilum. Generalized pleural infection is usually avoided because the remaining lobe rapidly becomes adherent to the parietal pleura when the lobe is caused to expand by the negative intrapleural pressure that is created by the air-tight, water-seal drainage system. When, however, the remaining lobe fails to expand satisfactorily, infection of the generalized pleural cavity may be severe and has occasionally proven fatal. When the upper lobe has been resected, the lower lobe usually fails to expand sufficiently to fill the upper portion of the pleural cavity. Even when the upper lobe has not been removed, air that is admitted into the pleural cavity at the time of operation may become trapped in the dome of the thorax and fail to be evacuated by the drainage tube that is customarily anchored at the bottom of the pleural cavity. If the dome of the pleural cavity does not soon become filled with lung, an apical empyema and bronchopleural fistula are liable to develop and persist in spite of prolonged adequate drainage; the empyema must then be obliterated by an extrapleural, or an extrapleural and Schede thoracoplasty.

Hæmorrhage from the hilar stump both during and after operation is a major danger of the one-stage technic. Occlusion of the great pulmonary vessels until they have been closed by suture depends upon the tourniquet instrument and its cord not slipping or breaking. I know of two cases in which the hilar stump slipped from the grasp of the tourniquet; the hilum was grasped, the hæmorrhage was checked and the patients recovered. In another patient of whom I have heard, death from hæmorrhage occurred on the operating table after the hilum had been sutured and the tourniquet released.

Delayed hæmorrhage from the hilar stump is a relatively frequent com-

plication in the series of cases with which I am familiar. Roberts and Nelson report the following three cases of post-operative hæmorrhage among ten patients: (1) One pint of blood passed through the drainage tube within four hours after operation; the chest was reopened and a small spurting artery in the divided pulmonary ligament, which had not bled at the time of operation, was secured; a bronchopneumonia and wound infection developed but the patient made a complete recovery. (2) Six hours after operation a definite trickle of blood was seen passing through the drainage tube; the tube was clamped for twelve hours, "Coagulin" was injected into the pleural cavity and no further bleeding was observed; the patient completely recovered. (3) Fourteen days after operation a sudden, severe hæmorrhage of at least three pints occurred; a basal empyema cavity was opened but the bleeding had already ceased and did not recur; a wound infection and a subphrenic abscess developed; the patient completely recovered.

One of Brunn's eight one-stage lobectomy patients died from a post-operative hæmorrhage which was not discovered in time for effective treatment because the drainage tube had accidentally become kinked. Shenstone and Janes have occasionally observed post-operative hæmorrhage, which presumably came from the hilar stump, but no patient died from it.

Edwards has not as yet reported what hæmorrhage complications, if any, he has experienced in his forty-eight one-stage lobectomy series. I have performed the Brunn-Shenstone-Janes one-stage lobectomy operation in only three patients. No hæmorrhage occurred in the first patient in whom the upper lobe was removed for a tremendous and almost fatal hemoptysis from a non-syphilitic aneurism of a pulmonary vein. In the second patient signs of bleeding appeared twelve hours after a basal lobectomy for bronchiectasis; twenty-two hours after operation the chest was reopened and a slow but steady oozing of blood was seen coming from the edge of the hilum at the superior limit of the pulmonary ligament. In the third patient the upper and middle lobes were removed for malignant disease which did not involve the hilar bronchi; one hour after operation the patient's condition was satisfactory; he then suddenly developed the signs of hæmorrhage; several minutes later there was a gush of blood from the air-tight drainage tube and death quickly followed. At autopsy the forcing of water into the pulmonary vein showed three small openings in the hilar stump that had been sutured with approximately a dozen interrupted interlocking mattress sutures.

It is impossible to see and separately to ligate all of the pulmonary vessels in the hilum after it has been divided and while it is being squeezed by a tourniquet. The cut surface of the hilum has a rather homogeneous appearance except for the stiff-walled bronchi. An attempt is made to seal the entire cut surface with one or more layers of continuous or mattress sutures, many of which probably pierce large pulmonary vessels. It is apparent that such sutures may fail to seal the entire surface of the divided hilum, which is from four to five centimetres long. When the tourniquet is released, bleeding almost invariably occurs from one or more vessels that had not been secured by the first sutures; such bleeding vessels may be easily closed with additional

sutures. In my cases and, presumably, in those of the other surgeons who have used the Brunn-Shenstone-Janes one-stage lobectomy technic, the divided hilar surface has been perfectly dry at the time the incision in the thoracic wall was closed. It is likely that those vessels that bleed only after the conclusion of the operation were crushed by the temporary application of the powerful tourniquet and were forced open only when the blood-pressure rose after operation. Since all of the vessels cannot be seen on the cut surface of the hilar stump and since those that may escape closure by the hilar sutures do not necessarily bleed immediately after removal of the tourniquet, the conclusion must be accepted that an attempt to seal the entire hilar surface with "blind" sutures does not necessarily exclude the possibility of a post-operative reactionary hæmorrhage.

The hilum is usually sealed by two layers of continuous sutures that are passed into and out of the divided surface of the hilum and do not include the pleural edge of the hilum. Interrupted interlocking mattress sutures are perhaps more secure than a continuous suture. After removal of the tourniquet a second line of defense against hæmorrhage is provided by the next row of sutures that includes the periphery of the hilum and folds it over the first row, or rows, of sutures. The incision that effected amputation of the lobe should have been made so that the visceral pleura was divided approximately four centimetres distal to the tourniquet cord; the central point of the incision should be not less than one centimetre distal to the tourniquet cord. The resulting cone-shaped excavation of the hilum permits an infolding of the periphery of the hilum and apposition of visceral pleura to visceral pleura. Care should be taken that the incision in the hilum should not pass nearer than one centimetre to the tourniquet cord; if it did, the hilum might collapse and the tourniquet loosen with resulting terrific hæmorrhage. A third line of defense against hæmorrhage, as well as against the formation of a broncho-pleural fistula, is obtained by tacking the end of the sutured hilum against the adjacent interlobar surface of the remaining pulmonary lobe.

Tension pneumothorax is another danger, though a remote one, of the one-stage lobectomy technic. Since the incision in the thoracic wall remains completely closed after operation, the air-tight drainage tube serves as the only exit for air that might pass into the pleural cavity through a one-way valvular type of bronchopleural fistula that might form unexpectedly at any time during the first one or two post-operative weeks. If the drainage tube should have become occluded by a clot of fibrin or by kinking, if expansion of the remaining lobe and its adhesion to the parietal pleura should cover the tube's openings, or if the tube should already have been removed from the chest, air escaping from a valvular type of bronchopleural fistula would find no egress but would accumulate in the pleural cavity and might cause fatal pressure upon the mediastinum. In one of my three one-stage lobectomy patients, the air-tight drainage tube had functioned perfectly during the first fourteen post-operative days and there was no evidence of a bronchopleural fistula; the tube then accidentally became kinked; a bronchopleural fistula developed; the patient was discovered in a state of cardiorespiratory collapse;

the first person who saw the patient did not recognize that the drainage tube had become kinked but fortunately the second person did and the patient recovered from the immediate consequences of the accident but died two weeks later from a brain abscess or meningitis.

A tension pneumothorax occurring within the first two weeks after operation would probably rupture the adhesions that had formed between the remaining lobe and the thoracic wall; the bronchopleural fistula would probably then infect the entire pleural cavity. An empyema involving the dome of the pleural cavity in the presence of a bronchopleural fistula only occasionally becomes obliterated when treated by drainage; an extrapleural, or an extrapleural and Schede thoracoplasty, is usually eventually necessary in order to obliterate such an empyema.

TWO-STAGE LOBECTOMY

The two-stage lobectomy technic with which this article is concerned consists, at the first stage, of separation of the pleural adhesions over the diseased lobe, and gentle stroking with gauze of the visceral and parietal pleura of the entire hemithorax in order to produce a reactionary inflammatory barrier against the pleural infection that will occur after the second stage of the operation, and in order to create firm pleural adhesions over the lobe that is not to be removed. At the second stage the adhesions that have formed over the diseased lobe are separated and the hilum of the lobe is tightly ligated with a special automatic ligating instrument. The lobe is then resected approximately three or four centimetres distal to the ligature and the incision in the thoracic wall closed; the residual pleural space is drained by an airtight tube. This brief description of the operation includes several important technical improvements which have been made during the two years that have passed since I described the operation in 1933. These improvements will be considered in the paragraphs to follow.

An incision in the seventh intercostal space, and resection of two or three centimetres of the extreme posterior ends of the one, two or three ribs adjacent to the intercostal incision is probably preferable to removal of the sixth, seventh and eighth ribs between the vertebral transverse processes and the posterior axillary line, which I recommended in 1933. My colleague, Cameron Haight, has suggested that retention of these portions of the sixth, seventh and eighth ribs probably assists the patient in expectorating the bronchial secretions during the ten or twelve days between the stages of the operation.

It is more difficult, but not impossible, to divide extensive pleural adhesions through an intercostal incision than through one in which the entire posterior portions of three ribs have been resected. Since even a long intercostal incision does not always afford a sufficiently broad access to the pleural cavity, the extreme posterior ends of the one, two or three ribs adjacent to the intercostal incision may be sectioned in order to permit a wider spreading of the intercostal incision. Linear division of these ribs, which is customarily recommended, may result in severe pain during coughing because of rubbing

together of the costal ends; so as to avoid this complication the extreme posterior two or three centimetres of these ribs should be resected.

During my early experience with the two-stage lobectomy operation I occasionally found at the second stage that a part of the undiseased upper lobe was not adherent to the parietal pleura, being separated from it by a walled-off collection of pleural fluid that had been produced by the trauma of the first stage and that had not been drained by the aspirating needle that I then used at suitable intervals between stages. Adhesion of the upper lobe to the parietal pleura has been satisfactory since I have introduced, at the first stage, two air-tight drainage tubes, split spirally in their intrathoracic portions, into the pleural cavity from the bottom of the costophrenic sinus; one of these tubes should be passed upward from the posterior axillary line for approximately twelve or fourteen centimetres in the costovertebral gutter, and the other from the anterior axillary line for sixteen or eighteen centimetres in front of the upper lobe. A week after the first stage the anterior tube may be withdrawn for several centimetres and completely removed at the time of the second stage. The posterior tube should be retained until the residual pleural hole that remains after removal of the lobe at the second stage has become completely obliterated, but most of the spirally-split interpleural portion of this tube should be removed during the second operation.

The most important improvement that has been made in the operative technic that I described in 1933 is concerned with ligation of the lobar hilum during the second stage. In a number of my patients the tightest possible ligation of the hilum failed to cause complete occlusion of the pulmonary artery in the indurated hilar tissues. In several instances, the additional application of a tight ligature of a live rubber tube failed to close the artery, which was finally closed only after one, two or three ligatures of heavy silk or rubber had been added at intervals of twelve or twenty-four hours. Unless the artery as well as the vein is completely closed, wet rather than dry gangrene of the lobe occurs and a considerable amount of blood is lost into the lobe and thence onto its surface. My colleague, Duane Carr, has devised a small flat metal box* containing two dogs that prevent a loop of cord, passed around the hilum of the diseased lobe, from loosening after it has been tightened by a mechanically powerful handle. After the loop has been tightly applied the handle of the instrument is unscrewed from the box through which the cord passes; the box is left in position until it falls off when the gangrenous portion of the hilum spontaneously separates from the living portion where they are demarcated by the cord ligature. If at any time after the automatic ligature is applied, swelling of the lobe should indicate that the artery is not completely closed, the handle may be reattached to the head of the instrument, the ends of the cord reattached to the handle, and the loop around the hilum further tightened. My associates and I have used this instrument in our last five patients, in all of whom the artery was completely closed by the first application of the automatic ligature.

* Manufactured by the Geo. P. Pilling Son and Co., 23rd and Arch Sts., Philadelphia, Pa.

Until Carr's automatic ligature instrument became available, ligation of the hilum by hand did not offer sufficient certainty of complete permanent occlusion of the pulmonary vessels to justify immediate resection of the lobe and closure of the thoracic-wall incision. During the period in which I used ligation by hand and in the first two patients in which Carr's instrument was used the lobe was left in place for several days. When the lobe was seen to be in a dry-gangrenous condition it was cut away with scissors approximately four centimetres distal to the hilar ligatures, and the pleural hole, from which the lobe was removed, packed open. In the last three patients, in whom the automatic ligature was used, I felt reasonably certain that the pulmonary vessels were securely closed and that immediate amputation of the lobe three or four centimetres distal to the ligature was safe. Therefore, the lobe was amputated, no ribs were resected, the intercostal incision was firmly closed and the posterior air-tight drainage tube was retained, its inner end being tacked to the dome of the diaphragm as in the Brunn-Shenstone-Janes technic; an air-tight tube was introduced into the lower pleural cavity for antiseptic irrigations. The drainage tube provided for discharge of the disintegrated gangrenous hilar stump and for secretions from the infected lower pleural cavity that remains after resection of the diseased lobe. The long ends of the hilar ligature were passed together through an intercostal space and through the skin at the level of the dome of the diaphragm; the ligature and the attached little metal box should be removed through a small incision in the intercostal space not less than sixteen days after the second stage of the operation.

The procedure that was described in the preceding paragraph has the great advantage of permitting completion of the entire two-stage lobectomy through an intercostal incision and of not requiring open packing of the pleural space that had been occupied by the resected lobe. The closed drainage tube assists the remaining lobe to expand and the diaphragm and mediastinum to shift and close the residual pleural space. If a residual empyema cavity should persist it would probably be a small one and should heal after open drainage. If a large bronchopleural fistula should persist it could be closed by applications of 40 per cent. silver nitrate solution or by a muscle plastic operation. Closure of the incision in the thoracic wall has the disadvantage of exposing the patient to the same danger of tension pneumothorax that exists after a one-stage lobectomy, should a valvular bronchopleural fistula develop, and should the drainage tube become kinked or otherwise occluded. The chance of this combination of circumstances is, however, small.

Several surgeons who have adopted the two-stage operation use the first stage as I have described it, but at the second stage resect the diseased lobe, suture the hilar stump and close the thoracic wall, except for an air-tight drain, as in the Brunn-Shenstone-Janes one-stage technic. This method of removing the lobe has all of the advantages offered by the method that I have just described and the additional advantage that an automatic ligature box and gangrenous hilar stump are not even temporarily retained in the body. Temporary retention of the box and stump, however, constitutes a minor

disadvantage. The danger of reactionary or secondary hæmorrhage from the sutured hilar stump is so great (see the section on one-stage lobectomy, in which the experience of various surgeons with hæmorrhage has been cited) that I feel that suture should not be relied upon to secure the pulmonary vessels but that they should be entrusted to the far more certain action of the powerful circumferential automatic ligature.

MISCELLANEOUS CONSIDERATIONS

A number of other suggestions as to lobectomy have been made by various surgeons. Archibald has emphasized that the more severe the pulmonary infection, the greater the risk. Patients should not be operated upon during, or for several weeks after, an exacerbation or extension of the pulmonary infection.

In cases of bronchiectasis all five lobes of the lungs should be studied by means of iodized oil bronchograms so that the exact extent of the disease may be definitely known. If only the basal lobes are studied, because only one or both of them are suspected of being diseased, a single lobectomy may be followed by disappointment in the discovery of some other diseased lobe. It is usually best to introduce the iodized oil in two or three stages. The lobes on the right side may be injected at one sitting and those on the left side several days later. If the supraglottic method of injecting the iodized oil should be unsatisfactory, as it is in some adults and many children, the oil should be introduced through an intrabronchial catheter. Each injection of the oil should be preceded and followed by a thorough postural drainage.

Several surgeons have successfully resected the right lower and middle lobes, or the left lower and that part of the left upper lobe which corresponds to the right middle lobe. Both lobes should be removed at the same operation. Eloesser has successfully removed both lower lobes for bronchiectasis. We have undertaken to perform bilateral two-stage lobectomy of two or more lobes in four patients; in three of these the operations on the first side were successfully concluded; one patient died from massive collapse of the right lower lobe two weeks after her right middle lobe had been removed and several months after the removal of the left "middle" and lower lobes; the fourth patient died from progressive cavitation in both lungs about two months after removal of the right lower and middle lobes.

I agree with Churchill that a temporary phrenic nerve paralysis is preferable to a permanent one before a unilateral lobectomy is performed. Paralysis of the hemidiaphragm hastens closure of the pleural space that remains after removal of the lobe; return of diaphragmatic function is desirable from the point of view of respiratory function. In patients in whom bilateral lobectomy is contemplated, and in whom operation upon the second side may be desirable before the temporarily paralyzed diaphragm on the side of the first lobectomy has resumed function, it may be best not to paralyze the diaphragm on the side that is first to be operated upon. The phrenic nerve, however, might be advantageously lightly pinched just above the diaphragm so as to produce a

brief diaphragmatic paralysis to facilitate the operation and immediately decrease the size of the space left by removal of the lobe.

Induced pneumothorax has been occasionally advocated as a desirable measure preliminary to lobectomy. Sometimes it greatly reduces the amount of sputum and, in such cases, probably decreases the risk of post-operative aspiration or stasis pneumonia. I feel, however, that this advantage is of less importance than the risk that is run of producing an empyema, or a pleural effusion and stiffening of the visceral pleura that would tend to delay or prevent eventual expansion and adhesion of the undiseased lobe.

Bethune has proposed the production of a pneumothorax, the introduction of a thoracoscope into the pneumothorax space and inflation of a powder through the thoracoscope so as to coat the pleural surface and cause adhesion-formation after abandonment of the pneumothorax. I have not used this somewhat complicated procedure. It may prove to be of value if experience shows that the powder consistently produces sufficiently firm pleural adhesions over the undiseased lobe to prevent collapse of this lobe at the time of the lobectomy operation and yet does not produce such firm adhesions over the diseased lobe as to make their division at the time of operation too difficult or dangerous.

Intratracheal anæsthesia with intermittent aspiration of tracheal or bronchial secretions is used by some surgeons. I have not yet employed this procedure but I believe that further experience with it may conclusively demonstrate its value. When intrabronchial secretions are not aspirated during operation it sometimes becomes necessary to remove them immediately after operation by means of a bronchoscope; the resulting relief of dyspnœa and anoxæmia is dramatic.

Churchill prefers to extend the interval between the first and second stages to two or three months. He has found that during this time his patients gain weight, raise less sputum and are in better general condition for the second stage than if only ten or twelve days have elapsed between stages. Only exceptionally has Churchill had difficulty in dividing the pleural adhesions over the diseased lobe at the second stage. In this connection it is interesting to recall that even the pleural adhesions that have formed as the result of an empyema may sometimes be divided without great difficulty several months after the empyema has become closed.

PNEUMONECTOMY

Until three years ago no patient had ever recovered after a certainly complete removal of one lung. As a consequence, carcinoma involving the main stem bronchus, and bronchiectasis involving the entire lung were considered virtually hopeless diseases except for such relief as could be obtained by palliative measures. In 1931, Nissen successfully removed the entire left lung in two stages for bronchiectasis; Windsberg, Haight, Alexander, Mason, Van Allen and Overholt (for abscess) have since had similar successes. Evarts Graham and Singer, in 1933, were the first successfully to remove an entire lung for carcinoma. Since then, technical operative success has been obtained in re-

moving the lung for carcinoma or sarcoma by Archibald, Rienhoff (two cases), Overholt (two cases), Churchill (three cases), Flick, Haight. Perhaps other surgeons, of whose cases I do not yet know, have attained technical success with the operation of total pneumonectomy. My only patient who had pneumonectomy for carcinoma died thirty-two days after operation; he was out of bed two weeks after operation; his previously diseased heart fibrillated and, in spite of intermittent improvement, was responsible for his death; at autopsy there was no gross or microscopical evidence of any remaining malignant tissue. Excellent articles on pneumonectomy, which should be consulted by the reader, have been recently contributed by Archibald, Graham and Singer, Haight, Heuer, and Rienhoff.

Haight has made the interesting observation that all of the successful total pneumonectomies for bronchiectasis have been performed in two or more stages and all of the successful pneumonectomies for malignant disease have been, so far as he knows, one-stage operations. The protection afforded to the parietal pleura and mediastinum by a two or more stage operation might be expected to reduce the infectious risk in a bronchiectatic patient. In most patients who have bronchial carcinoma in an operable condition, complicating suppurative phenomena in the lung are not prominent and the danger of grave pleural and mediastinal infection after a one-stage pneumonectomy is, therefore, less than it would be in bronchiectatic patients. In carcinoma patients a pre-operative pneumothorax should be induced to aid the röntgenologist in diagnosing possible extrapulmonary metastases and to cause the patients' cardiorespiratory system to adapt itself to the physiological change that will obtain after pneumonectomy.

It is fortunate for patients with carcinoma of the stem bronchus that a one-stage pneumonectomy is relatively safe. Complete removal of the growth in the bronchus frequently requires that the pulmonary vessels be separately ligated and the stem bronchus dissected free from the mediastinal structures and divided close to the bifurcation of the trachea; also, occasionally, resection of glands from the mediastinum is indicated. Isolation and ligation of the pulmonary vessels in the hilum and dissection of the bronchus and lymph-glands in the mediastinum would be both difficult and dangerous at the second stage of a two-stage pneumonectomy because of the traumatic inflammatory infiltration in the hilum and mediastinum, and the friability of the structures that would follow the first stage of the operation.

In cases of bronchiectasis, prolonged infection in the lung usually causes the hilar structures to become matted together by inflammatory tissue that would make isolation and ligation of each of the thin-walled pulmonary vessels highly dangerous. Since it is unnecessary for the surgeon to remove the hilum or the intramediastinal portion of the bronchus when performing a pneumonectomy for bronchiectasis, the hila of the lobes or the hilum of the entire lung may be circumferentially ligated. Haight has had the experience of being obliged to ligate the hilum of the entire lung, rather than the hila of the lobes separately, because the interlobar fissure was firmly fused by adhesions. Though the hilum, stiffened by fibrous induration, was ligated as

tightly as possible by hand with heavy silk and a rubber tube, the pulmonary artery was only partly occluded and wet rather than dry gangrene of the lung resulted. During the following few days two additional but unsuccessful attempts were made completely to close the artery; finally a Bethune tourniquet, which was left in place, closed the pulmonary artery; a series of increasingly severe hæmorrhages from the pulmonary artery ensued, ending in the patient's death. At autopsy an ulcer was seen in the friable wall of the incompletely thrombosed pulmonary artery where the ligatures had been applied close to the pericardium; it was also seen that ligation of the pulmonary artery within the pericardium, which had been considered as an emergency measure, would have failed to check the hæmorrhages because the intrapericardial portion of the right pulmonary artery is very short and, in this patient, was infected and friable. Haight concludes that a similar accident should be anticipated in any patient whose hilum is much indurated as a result of chronic infection. He feels that the hilum of each lobe should, whenever tough interlobar adhesions do not prevent separation of the lobes, be separately ligated because the lobar hilum is more easily compressed than the hilum of the entire lung and because a greater length of the pulmonary vessels would remain between ligatures and the heart to become thrombosed. Should it be necessary to ligate the hilum of the entire lung, Carr's automatic ligature should be applied to the hilum as far as possible from the pericardium; this instrument is so powerful that it is probably capable of completely and immediately occluding the pulmonary artery; if it should fail at the first application, a second tightening of the ligature, when the hilar tissues had become somewhat softened from the previous pressure, would almost certainly shut off the artery. This same instrument should be used if the lobar hila are to be ligated.

A two-stage pneumonectomy operation with circumferential ligation of the hila of the lobes or the hilum of the lung should be performed through a posterolateral incision because this affords the surgeon access to the entire pleural cavity, and especially good access to the dome of the pleura and the costovertebral gutter where strong adhesions are likely to be met in cases of bronchiectasis. Archibald has indicated that an anterior incision in the thoracic wall is usually best when a one-stage pneumonectomy is intended for bronchial carcinoma; such an incision gives immediate access to the pulmonary vessels in the anterior portion of the hilum and usually gives sufficient access to what few pleural adhesions are likely to be present in cases of operable bronchial carcinoma; a posterolateral incision gives poor access to the anterior surface of the hilum if the lung is bulky and stiff as a result of neoplastic and complicating inflammatory infiltration.

The clinical experience of several surgeons has shown that the entire space that was occupied by the lung may become obliterated by displacement of the mediastinum, diaphragm and costal thoracic wall. If a residual pleural space should become infected and if prolonged drainage and paralysis of the hemidiaphragm should fail to obliterate it, a thoracoplasty should be performed.

The fact that eleven patients have survived the period of surgical convalescence after resection of an entire lung for malignant disease, has done

much to stimulate interest in the diagnosis of bronchial carcinoma in the operable stage. However, numerous patients are still being referred to the surgeon and bronchoscopist in the inoperable rather than the operable stage because too few physicians at present realize that carcinoma of the lung is a relatively commonplace disease in middle age, as well as in old age, and that mild pulmonary symptoms which are not diagnostic of other disease may be the expression of an early phase of bronchial carcinoma demanding a röntgenogram and bronchoscopy.

Total pneumonectomy will probably always be a relatively dangerous operation. Even an exploratory thoracotomy, undertaken to determine the operability of a carcinoma, may prove to be an operation of gravity in an old person whose carcinoma has probably been growing for months and in whom anæmia, loss of weight and other signs of advancing malignant disease are indications of impaired general resistance, if not of metastases. The recent demonstration of the feasibility of pneumonectomy in man will probably greatly stimulate interest in the early diagnosis and surgical treatment of pulmonary carcinoma. As a direct result of this growing interest it is almost certain that a steadily increasing number of technically successful pneumonectomies, followed by prolonged freedom from recurrence of carcinoma, will be reported.

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SURGERY IN CHRONIC MIDDLE-EAR INFECTION

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The middle ear properly includes the Eustachian tube, tympanic cavity and the mastoid. While infection in one of the three portions presupposes some invasion in the other two, the discussion in this thesis will be limited to the surgical treatment of chronic persistent discharge in the tympanic area, whether this be continuous, intermittent or recurrent in type. It assumes that other therapeutic measures, pharyngeal therapeusis, antiseptic lotions, iodine and dusting powders, post-tympanic irrigations and ionization have failed, the mastoid invasion is latent rather than acute, and surgical relief is indicated for the persistent intratympanic suppuration. The conventional radical mastoidectomy will not be reviewed here. Otologists seem to be performing this with less frequency, unless the middle-ear infection is associated with infection equally pronounced in the mastoid area. Its menace to hearing from removal of a portion of the annular ring and failure to control discharge in such a large percentage of cases have brought it into increasing disfavor with corresponding acceptance of the approach by the auricular canal.

These tympanic measures fall into three main groups: (A) The conventional ossiculectomy; (B) the combined ossicular removal and drainage of the mastoid antrum by post-tympanic or attic approach, the so-called Tobey[1] operation; and (C) the modified attic drainage without ossicular removal, presented here by the author with statistical review.

(A) Ossiculectomy.—This is a time-honored and obvious procedure. After long-continued post-tympanic suppuration the cavity is matted with scleroses, hypertrophies and adhesive processes. Even without actual necrosis of the bony walls or ossicular chain, there is so much squamous-cell invasion, fibrosis and ossicular rigidity that the auditory equation in this area becomes negligible and the indication is to clear out infecting débris, removing malleus, incus, or their remnants, and sometimes with labyrinthine precaution, the stapes. Statistical results of this procedure are difficult to compile, but the consensus of opinion is that they are disappointing; control of infective discharge is far from constant, there is always danger of infecting the labyrinth and even the meninges, and the majority of otologists now seem to prefer to use it in association with the radical mastoid operation.

(B) Attic Drainage with Partial Mastoidectomy.—Tobey originated an interesting attic-antral type of mastoidectomy, operating through the auricular canal. Offending ossicular elements were removed and the mastoid antrum and at least the anterior mastoid cells were entered through the posterior wall of the tympanic cavity—guarding against injury to the

promontory which marks the basal turn of the cochlea, the round and oval windows. He assembled an interesting group of instruments for this purpose—curettes, probes, punches, small tympanic mirrors, some adapted from the Hartmann set.

Two obstacles interfere with this operation—first, the difficulty in securing more than a partial exenteration of diseased mastoid structure, and second, the inability of others to follow successfully the Tobey technic. Again, it is not certain that an open mastoid wound is more harmful than an obscured tympanic one, and the technic of operation is difficult.

The limitations in the Tobey procedure are in a measure the same as in the modified attic procedure of the third group—it is indicated when the diseased process is not amenable to topical treatment, is limited to the tympanic membrane, ossicles, attic and antrum, and particularly when the tympanic perforation is in Shrapnell's area. As advocated by Kopetzky,[2] the cholesteatomatous matrix is not removed but utilized as a valuable epidermal lining. By removal of the outer attic wall, lateral wall of the aditus ad antrum, and posterior canal wall, free access is obtained to the mastoid antrum.

(C) Modified Attic Drainage.—This is so named because drainage is usually obtained without actual removal of any part of the ossicular chain, the existing narrow and tortuous channel is enlarged to allow free passage from the aditus, and the operation does not actually enter the mastoid area.

The initial work upon this procedure was done in the Department of Otolaryngology of the University of Pennsylvania, and was first performed upon a patient with double otitis media and threatened mastoiditis, whose suppurative otitis media of many weeks' standing baffled all treatment. Control by modified attic drainage resulted in a dry ear, reformed tympanic membrane and reasonable protection of hearing.

Briefly, the procedure involves enlargement of the tympanic membrane in the posterior inferior quadrant—extending this upward into the attic area on that side, biting off when necessary portions of the overhanging scutum, and extending the opening to include any existing perforation even in the anterior portion of the tympanic membrane. The attic area is reamed out in the direction of the aditus, adhesions are cleared away, and margins of the aditus curetted by special curved curette. The malleus handle is pushed aside to obtain free drainage but not removed unless hanging free and obviously necrotic. Studies were made in the anatomical laboratory with Doctor Batson to ascertain the relative danger of injuring the facial nerve or stapedial articulation. Such injury, with ordinarily careful technic, appears unlikely.

The accompanying illustrations will demonstrate the operative method, and the instruments used. The procedure is a brief one, perhaps ten minutes in duration, and requires light general anæsthesia (Fig. 1). Its success will depend largely upon an adequate tympanic opening which is placed far enough posterior to avoid ossicular injury. A protective dressing is applied for twenty-four hours and then removed to permit post-operative irrigation

with antiseptic lotions if required. This operation is simple, comparatively free from danger and if unsuccessful interferes in no way with subsequent more radical measures.

An initial series of twenty-nine ears was reported[3] before the Section on Otolaryngology of the College of Physicians in April, 1931. In this

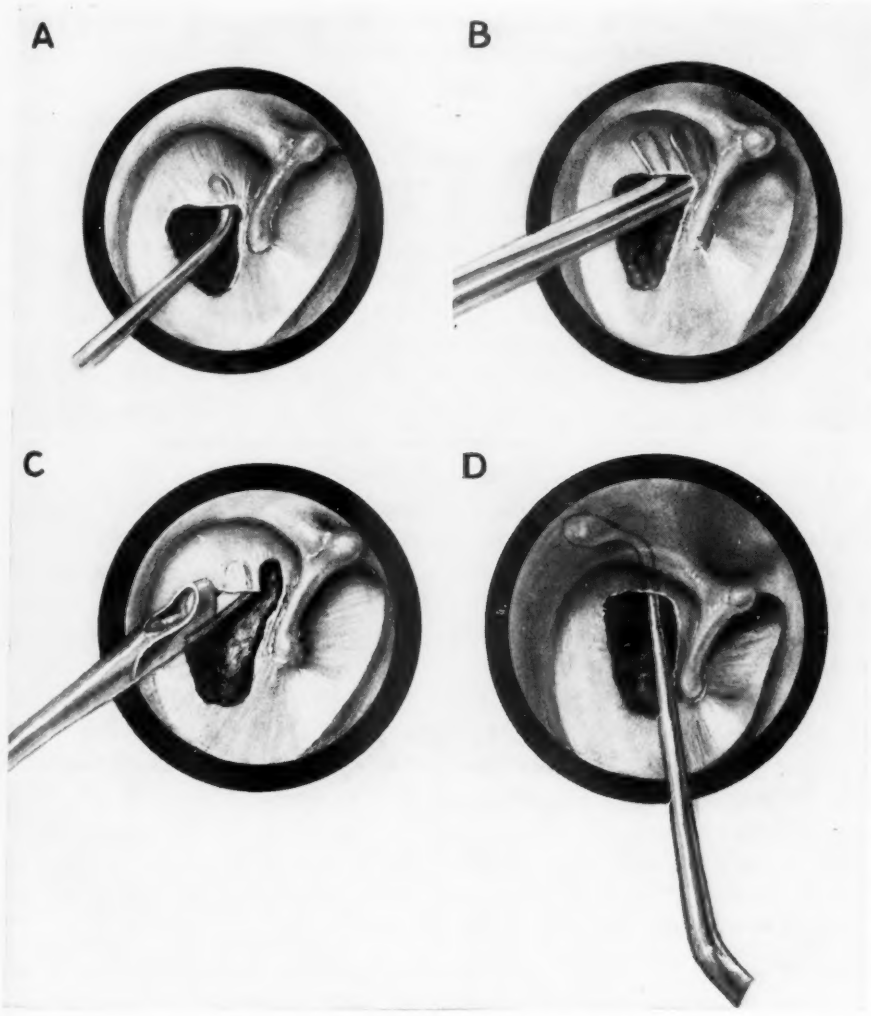

FIG. 1.—Modified attic drainage—stages of procedure.

group eighteen or 69.2 per cent. were dry at the time of the paper. There has been recurrence of discharge in a few instances since, but at least 50 per cent. have remained satisfactory—many with restored drumheads and presence of light reflex.

In May, 1932, before the Section on Laryngology, Otology and Rhinology of the American Medical Association, a more conclusive analysis was re-

ported[4] in connection with a paper on some studies on middle-ear infection. This analysis included sixty-one patients and as nineteen had bilateral infection, the list represented eighty individual ears. At the time of this presentation fifty ears, 62.5 per cent., were dry, 20 per cent. showed varying degrees of improvement and 17 per cent. no improvement. In three cases of preoperative labyrinthine complications with vertigo and falling sensations, two were completely and one partially relieved by modified attic drainage. In four cases of post-operative labyrinthine conditions, two transient and two quite severe, one with marked dehydration, and the other alkalosis, all recovered following this procedure. Attic drainage operations were performed in five cases of active mastoiditis, one a feeble patient of seventy-four years, in the hope of aborting mastoid involvement. Of the six individual ears of this group, only three were successful. The remainder required mastoid surgery. This modified procedure was attempted in three cases of continued offensive suppuration after previous radical mastoidectomies with cholesteatoma, with outcome indifferent. About thirty cases have been operated on since this list was published with uniformly favorable results.

Much has been written on the Aschoff and Wittmaack theories of the influence of infantile otitis in subsequent mastoid development, and Almour's[5] discussion of the rôle of squamous epithelium in middle-ear and mastoid changes is perhaps a timely corroboration of the theory. In the two types of infantile otitis media, catarrhal otitis neonatorum should be succeeded by a sclerotic mastoid and ordinariy infantile suppurative otitis media by a diploetic mastoid. Both of these conditions ought to create such a successful mastoid barrier that attic surgery is indicated. The diploetic mastoid presents much X-ray difficulty but its recognition is important for the success of many cases of attic drainage.

In conclusion, it might be said that success in modified attic drainage depends upon limitation of infective invasion to the attic and antrum of the mastoid, upon careful selection of cases relative to the sclerotic or diploetic mastoid state, avoidance both of traumatism in operation and excessive local after-treatment.

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EXCISION OF PELVIC AUTONOMIC NERVES FOR THE RELIEF OF PAIN FROM ADVANCED PELVIC CARCINOMA

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Cotte,[1] in 1925, proposed resection of the superior hypogastric plexus for the relief of pelvic pain. A few months later, Tisseraud[2] reported complete relief of intense pelvic and lumbar pain in a patient suffering from advanced pelvic carcinoma, by Cotte's operation. Since then, a number of reports have appeared which deal with resections of the pelvic autonomic nervous structures (usually the superior hypogastric plexus) for the relief of pain due to pelvic malignant neoplasms.

In the reports of twenty-nine patients (3, 4, 5, 6, 7, 8, 9, 10, 11) who were subjected to this type of surgery, and in whom the degree and duration of the relief had been clearly noted, twenty-one (73 per cent.) were relieved completely for the remainder of their lives. In some cases this was for as long as one or two years, though most of the women lived only a few months after the operations. There was no operative mortality. Jianu[11] reported nine patients, on whom he had performed most extensive sympathectomies extending from the renal plexus to, and including, the inferior hypogastric plexus. In this series there was an operative mortality of two (22 per cent.) but all of the patients who survived were completely and permanently relieved. The usual site of the pain was in the lower abdomen and back. Bernard and Theodoresco,[3] however, reported relief of pain in the legs and in one patient even in the heel. The authors quoted above were unanimous in denying any permanent untoward effects from these operations, although temporary incontinence of urine and fæces and atony of the bladder were observed. Reference was also made to the tendency to frequent defecation which followed pelvic sympathectomy and which sometimes proved difficult to control. There was never any impairment of either sensory or motor function of the extremities.

This report concerns the results of operations upon twenty-two patients from the Gynecologic Services of the University of Pennsylvania and Bryn Mawr Hospitals and the Radiologic Department of the Philadelphia General Hospital. All of the patients suffered from incurable pelvic carcinoma. In one instance the malignant growth originated in the vesicovaginal septum and involved the wall of the bladder. In the remaining twenty-one, the primary tumor was in the uterine cervix. All of these women had received pelvic irradiation, either radium therapy, high-voltage X-ray therapy or a combination of the two. Hysterectomy had been performed upon one subject two and a half years previously at another hospital. All of these patients

suffered from excruciating pain in the lower abdomen. In eighteen there was also pain in the sacral or rectal region of the back. Eight complained of pain in the thighs, two in the knees, and one had pain throughout the entire leg to the ankle. Their ages ranged from twenty-six years to sixty-three years.

The patients were selected on the following basis: (1) Their pain was intense and was not improved by irradiation therapy; (2) röntgenological examination of the pelvic girdle revealed no bone invasion; (3) blood-chemistry studies showed that the blood urea nitrogen was within the normal limits; (4) the hæmoglobin and erythrocyte estimations were 50 per cent. of normal or greater.

The details of the operation are as follows: With the patient in the Trendelenburg position, the incision is made in the mid-line from four centimetres above the umbilicus to the pubes. The liver, the paravertebral nodes and the pelvic organs are examined. The small intestine is packed into the upper abdomen, the sigmoid is drawn well to the left side of the pelvis, and the bifurcation of the aorta, the common iliac arteries and the sacral promontory are identified. The peritoneum over the promontory of the sacrum is now opened longitudinally in the mid-line. If the mesocolon is attached abnormally far to the right, the incision in the posterior layer of peritoneum is made close to the right common iliac artery, and, in such a case, the position of this vessel, as well as the mesial situation of the plexus which is to be removed, must be borne in mind. After incising the peritoneum, all nerve filaments are separated from it so that they can be excised with the plexus.

The peritoneal incision is enlarged to extend from the origin of the inferior mesenteric artery to the rectum. The peritoneum is then mobilized laterally as far as the common iliac arteries, exposing the ureters to view. In thin subjects, the fibres of the sympathetic plexus are visible through the loose areolar tissue which covers the prevertebral fascia and the left common iliac vein. This layer of tissue containing the sympathetic trunks is separated from the right common iliac artery, beneath the mesial margin of which glistens the fascia covering the bodies of the lumbar vertebræ. Following this plane to the left side of the interiliac triangle, the broad flat surface of the left common iliac vein is exposed to view. Separation of the retroperitoneal tissues from this vein is not without danger, due to frequent infiltration by malignant growth and because large anomalous vessels may enter the iliac vein in this region. The dissection is continued to the outer margin of the left common iliac artery. When this preperitoneal layer has been elevated, the superior hypogastric plexus, because of its great tensile strength, can be easily distinguished within it. The fibres of the plexus are followed upward and freed from the anterior surface of the aorta as far as the origin of the inferior mesenteric artery. They are likewise freed downward over the promontory and into the hollow of the sacrum to the posterolateral aspect of the rectum. The upper limit of the dissected plexus is

TABLE I

Successful Operations

Identity	Age	Location of Pain						Duration of Relief	Duration of Life	Cause of Death	Wound Healing	Remarks
		Abd.	Relief	Back	Relief	Legs	Relief					
E. G.	47	+	Yes	+	Yes	+	Yes	11 days	11 days	Uræmia	2	
S. O.	37	+	Yes	+	Yes	+	Yes	13 days	13 days	Uræmia	1	
A. H.	36	+	Yes	+	Yes	+	Yes	4 wks.	4 wks.	Exhaustion	1	
H. J.	34	+	Yes	+	Yes	+	Yes	3 mos.	3 mos.	Exhaustion	1	Pain in ankle
E. M.	43	+	Yes	+	Yes	+	Yes	4 mos.	4 mos.	?	1	Carcinoma vesicovaginal septum
V. S.	34	+	Yes	+	Yes	+	Yes	4½ mos.	4½ mos.	Hæmorrhage	1	Pain in knee
E. R.	54	+	Yes	+	Yes	–	–	10 days	10 days	Peritonitis	3	
R. A.	41	+	Yes	+	Yes	–	–	2 mos.	2 mos.	Exhaustion	1	
B. G.	40	+	Yes	+	Yes	–	–	4 mos.	4 mos.	Exhaustion	1	
F. J.	35	+	Yes	+	Yes	–	–	2 mos.		Living	1	
R. R.	38	+	Yes	+	Yes	–	–	2½ mos.		Living	1	
M. L.	59	+	Yes	+	Yes	–	–	6 mos.	6 mos.	Exhaustion	1	
E. J.	36	+	Yes	+	Yes	–	–	14 mos.		Living	1	
M. P.[b]	63	+	Yes	–	–	+	Yes	2½ mos.	2½ mos.	Exhaustion	1	
L. W.	29	+	Yes	–	–	–	–	3 days	3 days	Hæmorrhage	–	
A. S.	53	+	Yes	–	–	–	–	3 wks.	3 wks.	Peritonitis	2	

Table I.—Data relating to sixteen patients who were relieved of pain due to pelvic carcinoma by removal of pelvic sympathetic nervous structures arranged according to the location of the pain. "+" = pain present before operation. "–" = absence of pain. "Yes" = complete and permanent relief of pain. "?" = cause of death not determined.

TABLE II

Unsuccessful Operations

Identity	Age	Location of Pain						Time Since Operation	Duration of Life	Cause of Death	Wound Healing	Remarks
		Abd.	Relief	Back	Relief	Legs	Relief					
B. S.	39	+	Yes	+	No	+	Yes	2 mos.	Living	—	1	
M. C.	30	+	Yes	−	−	+	No	10 mos.	Living	—	1	
A. D.[b]	63	+	No	+	Yes	+	Yes		8 mos.	Uræmia	1	
A. D.[a]	45	+	No	+	No	−	−		3 days	Cardiac failure	−	Nerve fibres not found in specimen
M. P.[a]	47	+	Yes	+	Yes	−	No		3 mos.	?	1	Leg pain first began 8 days after operation
K. S.	26	+	No	+	No	+	No		2½ mos.	Exhaustion	1	Unable to resect plexus. Pain in knee

Table II.—Data relating to six patients upon whom sympathectomy was attempted for the relief of pain due to pelvic carcinoma and for whom complete and permanent relief was *not* secured. "+" = pain present before operation. "−" = absence of pain before operation. "Yes" = complete and permanent relief of pain. "No" = pain unaffected, recurred or first noticed subsequent to the operation. "?" = cause of death not determined.

severed. It is not only unnecessary to ligate before dividing but a ligature on the proximal end of the resected plexus may cause sensations of pain in the pelvis. Distally, the plexus bifurcates below the promontory and each portion is interrupted close to the uterosacral ligaments.

The field is next inspected and cleared of any remaining nerve filaments which might have escaped observation during the major part of the dissection. Bleeding from the small vessels supplying the plexus is controlled by pressure with warm moist sponges. The middle sacral artery, variable in size, lying in the mid-line, intimately related to the prevertebral fascia, should be avoided. The incision in the posterior layer of peritoneum is closed with a continuous suture, though untoward results have not followed imperfect closure of this structure due to carcinomatous infiltration. All removed tissue is subjected to microscopical examination in order to verify the removal of the sympathetic fibres and for their study.

In the series of twenty-two women who were operated upon for relief of pain, a successful result was obtained in sixteen (Table I), and in six (Table II) the results were unsuccessful. Two of our patients were less than thirty years of age. Nine were between thirty and forty; six between forty and fifty; three between fifty and sixty; and two were more than sixty years of age at the time of operation. It is interesting to note that both of these latter survived their operations and lived for two and one-half months and eight months, respectively.

The cause of death is pertinent only in relation to the operative mortality and to make the data complete. The term exhaustion was used in connection with patients who before dying progressively lost strength and weight. The usual post-mortem findings were: large, sloughing, fixed craters at the site of the primary growth, and frequently degeneration of the adrenals. Most of these patients also suffered from severe secondary anæmias and sometimes leukopenias. While five of these women survived their operations by less than two weeks, only two of these deaths, namely, those due to cardiac decompensation and peritonitis, can be fairly charged against the operation. On the other hand, the death from peritonitis three weeks post-operatively was unquestionably the sequel of the surgical intervention. This gives us an operative mortality of three (14 per cent).

Five patients in Table I, following sympathectomy, had a varying degree of anal pain which disappeared after control of obstinate diarrhœas. Three in the series who complained of post-operative pain in the region of the urethral meatus were made comfortable by irrigations with weak silver nitrate solution. One required incision and drainage of an ischiorectal abscess to relieve intense pain in the buttock, two months after a successful sympathectomy. None of these occurrences of pain was regarded as operative failures since the pain was peripheral in distribution and could be relieved by comparatively simple treatment. They emphasize, however, the need for close contact with sympathectomized carcinoma patients for the remainder of their lives.

Three of the operative failures in Table II deserve special comment. In the case of "A.D." (a), on microscopical examination of the specimen removed at operation it was impossible to find any nervous structures. Injury to the left common iliac vein in the operation upon "K.S." induced us to close the abdomen as soon as bleeding had been controlled and without performing the sympathectomy. "M.P." (a) was operated upon because of pain in the abdomen and back. This was completely relieved for the remainder of her life but eight days after her operation pain began in her left leg and continued until death. The remaining three patients had return of pain at some time after their sympathectomies, usually within two weeks.

Diarrhœa was an annoying symptom in a number of our patients. This could always be controlled with paregoric, bismuth and chalk mixture. Urinary incontinence occurred five times and two patients were incontinent of fæces but these complications cleared up spontaneously before the eighth day in every instance. Bladder atony was not observed as a complication. Although a number of our patients required catheterization, there was none who was unable to void after the seventh post-operative day.

In the course of these twenty-two operations, there were three serious accidents. On two occasions separation of an adherent plexus resulted in injury to the left iliac vein. In the third patient an anomalous branch from the aorta was torn close to its origin. In each instance the hæmorrhage was controlled with linen ligatures and the patient made a good recovery. One of these accidents occurred early in the series and was responsible for our failing to resect the plexus.

While this operation is not especially difficult for anyone familiar with pelvic surgery, it should not be attempted by the occasional surgeon. The proximity of vital structures to the field of operation requires that the operator be thoroughly familiar with the anatomy of this region, and the extensive adhesions or widespread metastases sometimes encountered will demand the ingenuity of the most experienced pelvic surgeon. This operation will not relieve pain due either to ureteral obstruction or to metastases to bone, or in any portion of the body other than that supplied by the pelvic autonomic nerves. It is neither time-consuming nor accompanied by a great degree of shock. It does not endanger sensory or motor function in the extremities. It is performed in a region familiar to gynecologists and does not require neurosurgical skill.

CONCLUSIONS

(1) Resection of the pelvic sympathetics relieved pain due to advanced pelvic carcinoma in 72 per cent. of selected cases.

(2) 33 per cent. of the failures were due to technical difficulties.

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NEUROCYTOMA OF THE KIDNEY

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The neuroblastomata usually have their origin in the medulla of the suprarenal gland. They may, much less frequently, arise in any part of the sympathetic nervous system. The occurrence of an extrasuprarenal neuroblastomata in the kidney serves as a basis for this report.

The anlage of the cortex and the medulla of the adrenal are as two separate organs. The cortex begins with the coelonic epithelium while the first anlage of the medulla is formed by migration of the sympathetic primitive cells. For this reason the clinical course and the pathological findings in tumors developing from the medulla or cortex of the adrenal are as distinct from each other as would be those developing from two different organs. Those tumors arising from the adrenal cortical tissues are hypernephromata while those arising from the medullary tissue are neuroblastomata. On account of this difference in the cortical and the medullary anlage in the adrenal, their location and their late union, displaced cortical tissue is much more frequent than the medullary. Pitt[1] reported a case in which subcapsular rests were found in a pair of kidneys which were made up of cortical and medullary adrenal tissues. Ulrich[2] has reported an entire adrenal in the subcapsular kidney tissue. These reports show that suprarenal inclusions may be in close contact with kidney parenchyma, and the tumor here reported probably illustrates one that has arisen from displaced suprarenal tissue in the kidney.

Case Report.—The patient, a white female, twenty years of age, was admitted to the Hospital of the University of Pennsylvania, on the service of Doctor Eliason, June 26, 1930, with a complaint of a mass present in the upper abdomen. The patient first noticed a lump in the upper left quadrant about one year before admission. From the time this mass was found to the time of admission to the hospital the tumor had slowly increased in size. Except for slight pain on respiration, there were no associated symptoms.

The physical examination disclosed a well-nourished and well-developed female. A prominent, large, rounded mass was felt in the upper left quadrant. It was firm and moved with respiration. The mass was not tender.

The cystoscopical differential kidney function studies gave evidence of a functionless left kidney. The right kidney functioned normally. The pyelographical studies were characteristic of a left renal tumor. There was no evidence of metastasis to any of the tissues.

The kidney and associated tumor were removed transperitoneally (Fig. 1). They measured twenty-one by sixteen by ten centimetres. A small amount of kidney tissue was thinned out over the upper pole of this mass. On section the tumor was partially cystic. It contained a thickened degenerated type of substance. The tumor tissue pro-

FIG. 1.—Photograph of the neuroblastoma of the kidney.

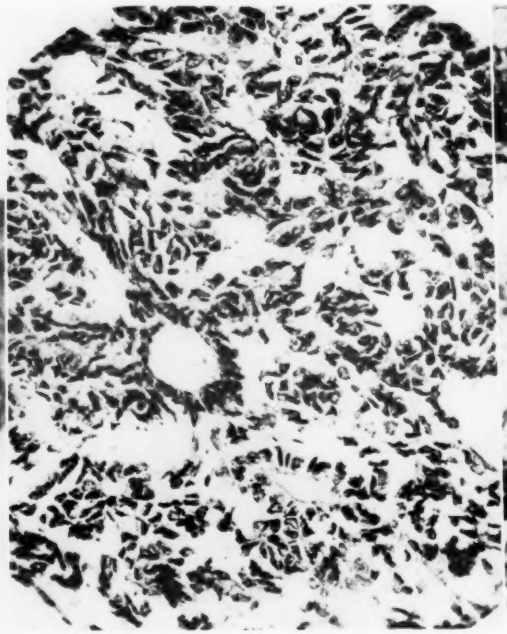

FIG. 2.—Photomicrograph of the neuroblastoma which shows the rosette formation of the cells.

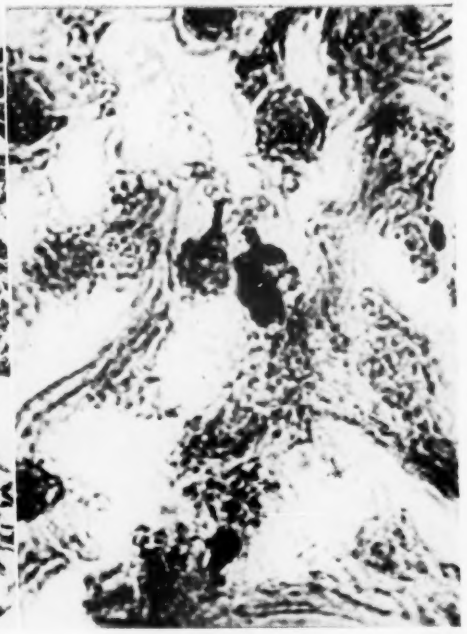

FIG. 3.—Photomicrograph of the tissue stained with a silver preparation. This shows the unapolar cells.

liferated somewhat irregularly into the cavity. It was yellowish-white in color, soft and friable.

The patient made an uneventful recovery. A follow-up examination August 9, 1932, showed that the patient had gained twenty pounds and had no complaints.

The pathological sections stained with hematoxin and eosin showed this tumor to be made up of a small embryonal type of cell with definite rosette formation (Fig. 2). This rosette appearance suggested that this tumor was of neuroblastic origin. Through the kindness of Doctor Alpers, special stains were made for neuroblasts and fibrils. The predominating cells proved to be the neuroblast type, some of which were apolar, unapolar, bipolar and multipolar forms (Fig. 3). The tissue stained for neuroglio fibres gave no definite evidence of fibrils. Doctor Alpers felt that the absence of nerve fibres and neuroglio fibres in many of the sections studied was due to the embryonic type of undifferentiated nerve cells. The diagnosis neuroblastoma of the kidney was based upon the finding of rosette forms and the polar cells in the tissues stained with the silver preparation.

Discussion.—It was Marchand,[3] in 1891, who first described this adrenal tumor as a reproduction of the anlage of the sympathetic nerve tissue, although a review of the histological descriptions of reported cases in the literature indicates that some of these tumors diagnosed as carcinomata were probably neuroblastomata. For example, Dalton,[4] in 1885, described a tumor of the left adrenal and liver in a boy, six years of age. In the pathological description he referred to the arrangement of fibrils. Amburg[5] reports a female two months of age, with an adrenal tumor. The description of the tumor referred to ball-like aggregation of tumor cells. Kuster,[6] in a report of two cases, refers to an aggregation of cells and fibrils which he regarded as closely allied to glioma. In one case, the tumor was found in an adult male. Richards[7] reports a male, two weeks old, with a tumor of the adrenal and liver. The description refers to ball-like arrangements of cells and the presence of fibrils. Although these cases were not diagnosed as neuroblastomata, a review of the microscopical descriptions indicates that they probably should have been so classified.

Wright[8] feels that the tumor involvement of the adrenal in such a large portion of cases, with simultaneous involvement of the liver or cranium in some cases, strongly supports the belief that other small cell tumors of the adrenal should be called neuroblastomata. The Hutchinson[9] and Pepper[10] types so frequently referred to in discussions on neuroblastomata were not identified as such by these authors. Hutchinson[9] in his paper directed attention to a clinical syndrome occasionally met with in children. He referred to ten cases of sarcoma of one or the other suprarenal with metastasis in the bones of the skull, while Pepper[10] gives a somewhat striking clinical character to a group of cases in which the adrenal tumor metastasized to the liver. These tumors were diagnosed as round cell or lymphosarcomata.

From these observations it is evident that a detailed study of most of the adrenal tumors that previously have been diagnosed in the literature as round-cell tumors, hypernephromata and carcinomata may undoubtedly prove that many of them were neuroblastomata.

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HYPERTHYROIDISM ASSOCIATED WITH PREGNANCY

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We have known for many years that the increased metabolic burden on the body during pregnancy demands an increased secretion of the thyroid gland. In some women this physiological hyperfunction stimulates the thyroid to such an extent that hyperthyroidism develops and in many patients it aggravates a state of hyperthyroidism that existed prior to conception. Recent experimental studies with the pituitary hormones have shown that these hormones can increase the secretory activity of the thyroid gland. In this paper I wish to present some experimental evidence of the relation of the anterior pituitary hormone to the activity of the thyroid gland, the chemical and physiological evidence of the increased secretion of the thyroid gland during pregnancy as shown experimentally in the lower animals, the relation of hyperthyroidism to pregnancy and the diagnosis and treatment of hyperthyroidism associated with pregnancy.

In 1929, Loeb and Bassett[1] reported the production of hyperplasia of the thyroid gland in the guinea-pig by the injection of anterior pituitary extracts. Later Collip, Selye, Thomson and Williamson[2] showed experimentally that the pituitary and thyroid can be definitely enlarged in the female rat by the prolonged administration of the anterior pituitary hormone and that the enlargement of both these organs ran approximately parallel to the weight increase in the ovaries. In another experimental study Collip and Anderson[3] injected rats with a highly purified extract of the anterior pituitary containing the thyreotropic factor. This was obtained from the residue after the removal of the growth hormone. These experiments showed that the thyreotropic hormone, which gives the complete replacement therapy in hypophysectomized rats, also produces an hyperplasia of the thyroid with hyperthyroidism in both the rat and the guinea-pig. Under the action of this substance, the animals lost weight, and Siebert and Smith[4] have shown that there is an increase in their metabolic rate. Hageman and McCordock[5] have demonstrated an increase in the heart rate and nervous irritability of guinea-pigs after the injection of this hormone. These experimental studies collectively demonstrate quite conclusively that the anterior pituitary hormone stimulates the activity of the thyroid gland and raises the question as to whether the hormone is responsible for the increased stimulation of the thyroid in pregnancy.

There has been considerable experimental investigation to demonstrate the chemical and physiological evidence of the increased secretion of the thyroid gland during pregnancy. This phenomenon has also been seen clinically in patients. Anselmino and Hoffman[6] have demonstrated the substance which has all the properties of thyroxin in the blood-stream of normal pregnant women. It was present in the first nine months, reached its maximum at term

and fell rapidly in the puerperium, being found in very small amounts on the sixth day post-partum. These determinations were also made on the blood of nine non-pregnant women, and this substance was found only in a very slight concentration. Likewise its concentration was either much lower in the fetal blood than in maternal blood, or, which was the rule, could not be demonstrated at all.

Anselmino and Hoffman[7] later injected rats and mice with the serum of a pregnant woman, and estimated the carbon-dioxide production. Their results indicated that uniformly it was greatly increased, whereas those injected with serum from a non-pregnant woman showed no change. Davies, Meakins, and Sands[8] showed that the minute volume of the heart is increased in proportion to the increase in metabolism. This increase in minute volume represents thyroid activity.

We have known for years that many women develop a definite enlargement of the thyroid gland during pregnancy. The frequency with which this occurs varies geographically; it is much more frequent in goitre belts. Some observers believe this enlargement is a pathological process; others that it is a physiological process which accompanies the increased secretion of the gland. Enlargement that occurs at puberty with each menstrual period has led many to believe that the enlargement of a preëxisting simple colloid goitre during pregnancy is pituitary in origin. Frazier and Ulrich believe that this enlargement may be expected to improve after the termination of pregnancy and the goitre which develops will be of a non-toxic diffuse type if the colloid is deposited normally, but a nodular type if it is deposited in a patchy distribution. Recurrent successive stimulations of the former result in a gradual diffuse enlargement, in the latter in coalescence of acini and the formation of adenomas.

The goitre may increase in size in subsequent pregnancies, but not necessarily develop toxic symptoms at any time. Occasionally pressure symptoms develop indicating the necessity of thyroidectomy. This is quite rare. Frazier and Ulrich[9] studied 1,350 women in whom a simple goitre appeared during an early pregnancy. Only twelve of this group required thyroidectomy. They feel that this observation is of significance in that it demonstrated how seldom it is necessary to perform thyroidectomy for a simple goitre during pregnancy.

Clinically, the increased activity of the thyroid gland may manifest itself early in pregnancy by the appearance of nervousness, increased irritability, tachycardia, *etc.* These symptoms exist in a mild or moderate degree. The basal metabolic rate may be within normal limits or slightly elevated. In the last two months of gestation these symptoms are more apparent, and the basal metabolic rate may be increased to plus fifteen to plus twenty-five. Some observers have noted the basal metabolic rate to be increased to plus thirty. Plass and Yoakum[10] made metabolic studies upon seventy-two women during a normal and non-complicated pregnancy, and found the metabolism was increased about 15 per cent. and fell to normal shortly after delivery. Sandiford and Wheeler[11] and Boothby and Sandiford[12] studied the metabolism daily during pregnancy and found a 25 per cent. increase in the last two months

of pregnancy. They concluded that the increased metabolism was due to the increase in protoplasmic mass of the fœtus.

It is not common for a patient to develop a toxic goitre during pregnancy. This has been proven by several extensive statistical studies that have been reported. However, toxic symptoms are made much worse in many patients that had a toxic goitre prior to conception. Seitz[13] reported a series of 112 cases in which the hyperthyroidism was made worse in sixty-eight, or approximately 60 per cent.; and in 25 per cent. of this 60 per cent., the thyrotoxicosis became so severe as to endanger the health and life of the patient. Gardiner-Hill[14] reported thirty-one pregnancies in seventeen women with hyperthyroidism. In his experience the hyperthyroidism was not made worse by pregnancy. Hyman and Kessel[15] feel that their experience is very similar to Gardiner-Hill. Falls[16] found that the toxic symptoms were usually aggravated by pregnancy but occasionally they are ameliorated.

Several observers have reported the decrease in fertility in patients suffering from hyperthyroidism. Gardiner-Hill[14] estimated it at approximately 50 per cent. and Mussey, Plummer, and Boothby[17] at about 25 per cent. of normal fertility. Mussey and Plummer[18] noted that in most of their cases the patients became pregnant during a remission of the disease. Diverse opinions exist as to the ultimate outcome of pregnancies complicated by hyperthyroidism. Seitz[13] reported a series of 112 cases, in which there were seven deaths, five therapeutic abortions, the induction of premature labor in eleven, thyroidectomy was performed during pregnancy in seven cases, three cases miscarried, three gave birth to macerated fœtuses, and three had "pretoxic influences." Gardiner-Hill[14] reported a series of patients in which twenty-three were traced, and in over 50 per cent. the pregnancies were not successful, and 50 per cent. of the patients who became pregnant the second time either miscarried or had a premature birth. Frazier and Ulrich[9] report a series of thirty-eight women who developed toxic goitres during pregnancy, and there was but one miscarriage. Eleven of these thirty-eight women had subsequent pregnancies before thyroidectomy; four of them had one additional normal pregnancy, two had two, and one had three. Two had one normal pregnancy followed by a miscarriage, one had one miscarriage, one had three miscarriages. No conclusions were drawn from this series but it is apparent that miscarriages were more frequent, when the thyrotoxicosis existed prior to conception. Mussey and Plummer[18] report a series of thirty-eight cases; thirty-seven were delivered of thirty-six normal children, and one still-birth following forceps delivery. These studies suggest that the cases that had a toxic goitre before conception have a less favorable outlook for a successful termination of pregnancy. At the Presbyterian Hospital from the years 1926 to 1932, inclusive, there were fifty-six women operated upon between the ages of nineteen and thirty-five. Fourteen were not married. Of the forty-two married women 60 per cent. had a history of one or more miscarriages before thyroidectomy. Twenty-three were followed up. Of these, twelve had had one successful pregnancy, and two had had two successful pregnancies after thyroidectomy. There was but one miscarriage. Three patients operated

upon during pregnancy had had a successful pregnancy since thyroidectomy. Apparently a subsequent pregnancy does not increase the possibility of a recurrence of the hyperthyroidism. None of the cases herein reported showed any evidence of a recurrence and Frazier[9] reported a series of twenty-eight patients without a single recurrence. Clute and Daniels[19] reported a series of fifty-three women who had become pregnant subsequent to thyroidectomy and only one developed recurrent toxicity.

The diagnosis of hyperthyroidism complicating pregnancy may be quite difficult at times. It is not uncommon for patients to have nervousness, tachycardia, and emotional instability during pregnancy and yet have no hyperthyroidism. On the other hand, persistent tachycardia may be the only symptom that would suggest hyperthyroidism. Falls[16] reported a group of patients who had been admitted to the hospital with the diagnosis of hyperemesis gravidarum, who proved later to have toxic goitres, with an acute crisis. Davis and Harper[20] had a similar case under their observation. Fifteen patients have been studied in the thyroid clinic of the Presbyterian Hospital during pregnancy subsequent to thyroidectomy, who had had one or more pregnancies prior to operation. With one exception the morning nausea was greatly decreased as compared with its severity in pregnancies before thyroidectomy. Standar and Peckham[21] studied the basal metabolism in a group of patients suffering from the toxæmia of pregnancy and found it to be above that which is found in a normal pregnancy. We are far from the goal of making accurate diagnoses in patients that do not present the clean-cut picture of a toxic goitre. One need only glance at the literature to arrive at this conclusion. Until recent times these patients as a whole were studied either from the obstetrical or surgical viewpoint. Surely there are many more cases than we find reported in the literature who present problems for diagnosis. If these cases were studied from the diagnostic viewpoint, by both the obstetrician and the surgeon, it would be very helpful in assisting our diagnostic ability, and help to clear the mist that surrounds our present understanding of this group of cases. When all the classical symptoms of hyperthyroidism are present, the diagnosis can be made with very little difficulty.

Several viewpoints exist as to the proper treatment of patients suffering from hyperthyroidism complicating pregnancy. It is frequently stated in the literature that these patients may be carried through pregnancy with medical management and in many instances after the termination of pregnancy, the thyrotoxicosis will be permanently relieved. We should not regard this too seriously. Recently at the Presbyterian Hospital five cases have come under my care that had been carried through pregnancy with hyperthyroidism as a complication and had prompt complete relief of symptoms after delivery, and the basal metabolic rate returned to normal, only to have a recurrence of symptoms at about the sixth or seventh week post-partum. The toxicity was so severe that thyroidectomy was necessary in all five cases; two refused operation. One case, reported elsewhere in detail,[22] returned to the hospital in a very severe crisis in the seventieth week post-partum, gave little or no response to Lugol's solution, had to be operated upon under adverse conditions,

and her case terminated fatally. This woman had been given iodine over a long period of time, and the usefulness of this drug was lost. In cases of physiological hyperactivity, rest in bed with or without the administration of small doses of Lugol's solution will usually abate the symptoms. It may be necessary in the latter months of pregnancy for the patient to have a repetition of these therapeutic measures. Caution should be used in the routine administration of iodine in this group of cases during pregnancy. As it is a well-recognized fact that patients suffering from an overactivity of the thyroid gland may develop a thyroid crisis with little or no warning, and if iodine had been given over a long period of time it may be of little or no benefit in combating this complication. In addition, adenomatous goitres may either be activated or made worse by the prolonged administration of Lugol's solution. Some patients require the administration of Lugol's solution for longer periods than others. However, when it is necessary that this be administered over a long period of time, the patient should be under the care of some one accustomed to the management and treatment of hyperthyroidism.

In the cases of mild hyperthyroidism, medical management should be instituted. In many instances the thyrotoxicosis will be controlled with little or no difficulty, and the patient may be carried through pregnancy under this management. After delivery, the status of the thyroid gland should be studied at intervals even though the delivery was uncomplicated. What the ultimate treatment of the thyroid will be will depend upon the clinical course. If the hyperthyroidism does not respond satisfactorily to the administration of Lugol's solution and rest in bed, or if there is a prompt return of symptoms after the cessation of the administration of Lugol's solution, surgical treatment is necessary. In the cases of severe thyrotoxicosis, frequently the life of the mother as well as the fœtus is endangered. Before the more rational therapeutic use of Lugol's solution was adopted, in many instances therapeutic abortions were performed or the patient was carried through delivery at the great possibility of losing the lives of both the mother and the fœtus. Often the strain of delivery under these conditions damaged the physical condition of the mother to such an extent as to impair her health subsequent to delivery. Experience has shown that abortion should not be performed in this group of cases and the dangers of this procedure in patients with hyperthyroidism have been repeatedly brought to our attention. Numerous contributions have been made which show conclusively that it is not safe for a patient suffering from hyperthyroidism to be given a general anæsthetic and to be operated upon for any condition other than surgery directed at the thyroid. In many instances severe thyroid crises have been precipitated and cases have been reported in which fatalities occurred after such minor operations as tonsillectomy, or extraction of teeth, in the presence of hyperthyroidism.

Every case must be considered individually and the decision to operate is based entirely upon the degree of toxicity. The pregnancy does not influence our judgment in advocating this procedure. In the past ten years thyroidectomy has been performed much more frequently during pregnancy, and

we have learned that it is not the hazardous procedure we once thought it to be. In the earlier cases surgeons were prone to operate upon these patients in the first four months of pregnancy. Subsequent experience has shown that thyroidectomy can be performed in the latter months of pregnancy when the degree of toxicity necessitates this procedure.

Mussey and Plummer[18] reported a series of forty-one cases of hyperthyroidism associated with pregnancy. In thirty-three of these cases a partial thyroidectomy was performed during pregnancy. Of the forty-one patients observed, thirty-eight were traced. They all showed improvement or relief of symptoms. There were no miscarriages, and one mother was delivered of a premature baby; one still-birth followed a difficult forceps delivery. Lahey[23] reported fifteen cases operated upon for a toxic goitre during pregnancy; there were no deaths. Fourteen delivered normally at term, and one case miscarried. Fabrini[24] performed thyroidectomy upon fourteen patients for toxic goitre during pregnancy; twelve had normal babies at term; one developed severe uterine bleeding (placenta previa), and one had a still-born baby. Falls[16] reported eight cases, seven of which were delivered normally at term, and one aborted before leaving the hospital. Frazier reported seven cases without any fetal or maternal mortality. Eight cases have been seen at the Presbyterian Hospital for which operation was recommended, two refused operation, one miscarried in the hospital before surgery could be performed, the remaining five were operated upon with no maternal mortality, and in these five cases the pregnancies were successful at term. Though none of these series is very large, taken collectively, excellent results have been obtained by surgical treatment; there was not a single maternal death, and the fetal deaths were surprisingly few. It is apparent that whatever fear was held for recommending thyroidectomy during pregnancy should be dispelled, when the degree of toxicity is such that this procedure is indicated.

SUMMARY AND CONCLUSIONS

(1) The experimental evidence of the relation of the anterior pituitary hormone to the activity of the thyroid gland has been presented.

(2) The chemical and physiological evidence of the increased secretion of the thyroid gland during pregnancy, as shown experimentally in the lower animals, has been presented.

(3) The increased activity of the thyroid gland during pregnancy should be classified as physiological and pathological hyperactivity.

(4) A study of the degree of activity of thyroid gland should be made in all cases of toxæmia of pregnancy that do not respond to the accepted therapeutic measures for this complication.

(5) Hyperthyroidism complicating pregnancy is not always relieved at the termination of pregnancy. Careful studies of the degree of thyroid activity should be made within two to four weeks post-partum.

(6) Mild hyperthyroidism complicating pregnancy may be controlled by medical management.

(7) Thyroidectomy should be performed in cases of severe hyperthyroidism during pregnancy and in the mild cases that are not controlled by medical management.

(8) When iodine is used during a pregnancy complicated by hyperthyroidism, it should be used with caution and under careful observation to prevent the loss of the beneficial effect of this drug, should thyroidectomy be necessary later.

(9) The termination of pregnancy is not indicated because of hyperthyroidism.

(10) Five cases have been reported upon whom thyroidectomy was performed during pregnancy. These five pregnancies terminated successfully and there was no fetal mortality. Three of these patients have had a successful pregnancy since thyroidectomy with no recurrence of the hyperthyroidism.

(11) If patients having hyperthyroidism complicating pregnancy or symptoms suggestive of this complication were studied by both the obstetrician and the surgeon or internist, our diagnoses would become more accurate and a better understanding of the therapeutics of this complication would develop.

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AFFECTIONS OF THE SPHENOPALATINE GANGLION

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A knowledge of the sphenopalatine or Meckel's ganglion and its affections has gained considerable importance since Sluder[1] in 1908 discovered the relationship that certain headaches and neuralgic sensations have to disturbances of this nerve-centre. In the past a great variety of ailments, ranging from neuralgia of the head to sciatica, have been treated by applications to or injection of this ganglion. It seems apparent that overenthusiasm has been responsible for many claims of pain relief without due consideration being given the neurological aspect or the transient psychic benefit that may result from an injection of this ganglion. When relief for such conditions as lumbago, sciatica, dysmenorrhœa and gastric pain are claimed without adequate explanation of the nerve connections involved, it naturally leads to a certain amount of skepticism in the minds of many, and tends to place a therapeutic procedure that does have a certain limited usefulness in considerable disrepute. This review will give consideration to only those neuralgic conditions that appear to have an anatomical and neurological basis for symptoms existing.

Anatomical Considerations.—Space will not be taken for review of the detailed anatomy of the ganglion, its branches and roots, as this can be obtained from any anatomical text-book. It would be well, however, to relate briefly its outlying connections.

The sphenopalatine ganglion may be considered as a nerve-centre acting as a terminus for the trigeminal, facial and sympathetic systems. The ganglion mass receives sensory impulses from practically all the lining mucosa of the nose, the maxillary, posterior ethmoidal and sphenoidal sinuses, the roof of the mouth, the upper two-thirds of the tonsils, the soft palate, the greater part of the pharynx and nasopharynx, and, in addition, taste fibres from the anterior two-thirds of the tongue. These sensory fibres pass for the most part through the superficial portion of the ganglion mass, not being in relation to the ganglionic cells, on their way to join the maxillary divisions of the fifth nerve. The ganglion is connected with the facial nerve by means of the superficial petrosal nerve, its motor root. A rather wide motor connection is given the ganglion when we consider that the facial nerve either directly or indirectly is connected with the following nerves: the acoustic, the otic ganglion, the sympathetic on the middle meningeal artery, the auricular branch of the vagus, the great auricular, the auriculotemporal, the lesser occipital, the trigeminal and the cutaneous cervical nerves. In addition, connections of the sphenopalatine ganglion to the sympathetic system by means of the great deep petrosal nerve open up possibilities for a great variety of indirect nerve associations.

Etiology and Pathology of Sphenopalatine Ganglion Disturbances.—The

disturbances of the sphenopalatine ganglion may be considered due to an irritation or inflammation of it which is usually secondary to inflammation of adjacent structures, namely, the posterior ethmoidal air-cells, the sphenoidal sinuses, the nasal mucous membrane and probably rarely the maxillary sinuses. Some cases are without doubt of systemic toxic origin without any pathological conditions of the nose or sinuses having been present.

The pathology of the tissues adjacent to the ganglion that sets up disturbances in its structure may be only an acute rhinitis that transmits its influence through the tissues of the sphenopalatine foramen to the ganglion situated often as close as one millemetre from the nasal mucous membrane. The ganglion is probably more often affected by inflammation in the posterior ethmoidal or sphenoidal sinuses. This inflammation may be suppurative or hyperplastic in character and affects the ganglion by an extension of the disease process or by a transmission of toxic products through the thin separating bony walls.

In addition to these exciting causes there must also be considered the factor of heredity as constituting a latent cause. This factor may show the primary instability to be in the endocrine system or in the autonomic nervous system.

Symptomatology.—The various connections of the sphenopalatine ganglion by means of its sensory, motor and sympathetic roots open up possibilities for a great variety of symptoms. The sensory distribution to the nose, throat and sinuses gives characteristic indications in these regions. An irritation of the motor root can produce neuralgias of the face and neck by its connection with the facial and the lesser occipital and cutaneous cervical nerves; can account for disturbances in the eye and mandibular regions by its connections with the ciliary and otic ganglion; can cause reflex otalgia by its connection with the tympanic plexus; and may account for a variety of visceral symptoms by its connection with the vagus. In addition, there may be motor phenomena of the soft palate from involvement of the motor fibres to the levator palati and azygos uvulæ muscles. The connections of the ganglion to the sympathetic system may give a great variety of symptoms largely of glandular and vascular structures, but also of involuntary muscular structures, and possibly also remote parts of the body which may send sensory impulses through the sympathetic by paths that are but little understood. Thus such conditions as hyperæsthetic rhinitis, hay fever, asthma, cardiac pains, angina pectoris, gastric pains, nausea and vomiting and, in addition, symptoms in remote structures of the body which cannot be explained except by attributing to the sympathetic system functions which have not as yet been scientifically proved, may possibly be caused by disturbances of the ganglion.

Sensory fibres in the sympathetic nervous system have been definitely stated to be dendrites of neurones which have their cell bodies in the posterior root ganglions; but they are transmitted by the sympathetic root only as a pathway. The sympathetic system in some way appears to be capable of transmitting afferent pain impulses, but to explain some of the phenomena seen after anæsthetizing the nasal ganglion, it is necessary to attribute to the sym-

pathetic system the power of transmitting afferent impulses which are not painful sensory ones. Asthma, as a nasal reflex, may be explained in such a way.

The affections of the ganglion can be considered as neuroses or neuralgias and give rise to several syndromes of symptoms depending on the part of the ganglion involved and severity and duration of the exciting cause. Due to the variation in the position of the ganglion and the differences in the shape and size of the adjacent sinuses, all parts of the ganglion are not equally affected by adjacent pathology. One part alone may be involved giving one series of symptoms, or several parts may be affected giving a combination of symptoms. It is quite possible for any one of the sensory, motor or sympathetic roots to be involved alone or in any combination, thereby giving a series of symptoms easily traceable to the particular root involved, or in the case of affection of several roots giving a distribution of symptoms of such variety and vagueness as to suggest a general neurosis. At times, mingled with the symptoms of ganglion involvement, may be indications of affection of other nervous structures due to the variation in position and size of these nervous structures and the sinuses. The great variation in size and shape of the sphenoid sinus brings it at times in close relation with other nerves besides those connected with the sphenopalatine ganglion. The cavernous sinus containing the third, fourth and sixth cranial nerves is situated just external to and above the body of the sphenoid bone. These may be involved by pathology in the sphenoid sinus. The first, second and sometimes the third division of the fifth nerve are in relation to the sphenoid sinus laterally and the optic nerve passes over the sinus and is often separated from it by only a thin layer of bone. A large sphenoidal sinus extending outward may encroach on the foramen rotundum containing the maxillary nerve or the foramen ovale containing the mandibular nerve, or the sphenoid fissure containing the ophthalmic division, and also the third, fourth and sixth cranial nerves. A prolongation downward of the sinus brings it in very close relation to the vidian nerve and a further prolongation downward brings it in close touch with the eustachian tube.

The symptomatology of sphenopalatine ganglion disturbances can therefore be divided into four syndromes: (1) A trigeminal maxillary syndrome. (2) A sensory facial nerve syndrome. (3) A sympathetic syndrome. (4) A local sphenopalatine ganglion syndrome.

The trigeminal maxillary syndrome gives symptoms referable to the distribution of this nerve such as pain at the root of the nose or inside the nose, pain in the upper jaw and teeth, itching of the hard palate or throat or stiffness or aching in the throat or sense of foreign body, feeling that the teeth are too long, and diminished sensation of the soft palate, pharynx and tonsils of the affected side.

The facial nerve syndrome shows itself in such symptoms as a diminished and delayed perception of taste on the affected side and certain motor signs, such as a suggestion of flattening of the face due to involvement of the innervation of the muscles of facial expression and a higher palatine arch on the

affected side, deflection of uvula from the affected side, and a deflection of the median raphé from the affected side in the act of swallowing.

The sympathetic syndrome gives symptoms of much wider distribution in its ordinary capacity as controlling vasomotor and secretory phenomena and also in its power of transmitting afferent sensory impulses through sympathetic connections with remote parts of the body. Its vasomotor and secretory influence is shown typically in attacks of hyperæsthetic rhinitis. This condition is apt to come on at any time of the year, is irregular in its duration and severity, and is not associated with the inhalation of the various pollens. The symptoms in such attacks are similar to those of hay fever but are apt to be more transient in character. At times there may be a persistant salivation.

Involvement of the sympathetic elements in the ganglion may also show itself in such symptoms as pain in, behind and about the eye; pain in the lower jaw and teeth; pain in the ear and mastoid extending back of the mastoid into the occiput, neck, shoulder, breast, axilla, and even down the upper extremity into the fingers; sometimes pain in the brow and upper part of the head and muscular weakness of the arm and shoulder; itching of the upper extremity, and tic douloureux.

While such a classification into syndromes is convenient for purposes of description, it is unusual to find any patient with symptoms of one type alone or all the symptoms of any one type. There is practically always a combination of symptoms belonging to two or more of these syndromes.

The typical picture of sphenopalatine ganglion neuralgia is pain beginning at the root of the nose or in or around the eye, extending over the maxilla and backward to the mastoid process to become most severe at a point five centimetres posterior to its tip; from here the pain extends backward into the neck, shoulder, scapular region and sometimes into the axilla and breast. In severe attacks it may go down into the arm and forearm and even to the fingers. The attacks may occur at any time without warning and may last from a few minutes to several weeks or even be more or less constant. In mild cases there may be only slight sensory disturbances as a sensation of tightness or drawing, of the teeth being too long, stuffiness of the ears, aching throat, itching of the hard palate, or stiffness or rheumatism of the neck and shoulders. In severe cases the pain may be like a ball of fire or a knife cutting or boring into a nerve. As isolated symptoms of ganglion neurosis there has also been mentioned glossodynia, otalgia, nausea, paraguesia, vertigo, scotomata, photophobia and asthma.

When once the nerve-centre has been affected, it apparently remains vulnerable for an indefinite time for the symptoms may be rekindled by fatigue, anxiety, apprehension, tribulation, anger, mental shock, strain or systemic toxæmias. Many of the cases are of long standing and have finally had an imbalance in their whole nervous mechanism becoming neurotic and going from one doctor to another seeking relief.

Diagnosis.—A diagnosis of sphenopalatine ganglion neurosis may be of great importance to the health and life of a patient. Many cases with ganglion

symptoms have been treated by the ordinary local therapeutic measures without relief when an injection of the ganglion may have given quick relief. On the other hand, being overly anxious to find the ganglion at fault has resulted in many cases being diagnosed and treated as ganglion neuralgia when there was present some other very decided cause for the existing symptoms, such as an impacted molar tooth, infected tonsils, hypertrophied turbinates, sinusitis, deviated septum, *etc.*

Practically all the symptoms of sphenopalatine ganglion neuralgia may be produced by lesions of the nerve-trunks supplying the ganglion, namely, the maxillary and vidian nerves. These nerves often lie in very close association with the sphenoid sinus or a posterior ethmoidal cell occupying the body of the sphenoid bone. When infection of these sinuses occurs it may readily involve these nerve-trunks at a point central to the ganglion and have no influence whatever on the ganglion itself. Therefore it is necessary to differentiate between a lesion of the ganglion itself and a lesion of the nerve-trunks involved in suppurative or hyperplastic inflammation in these sinuses. This differentiation can be made by a therapeutic test. Cocainization of the ganglion will stop the pain caused by a lesion of the ganglion and will have no effect if the lesion is involving the nerve-trunks central to the ganglion. On the other hand, intrasphenoid application of cocaine in the latter cases may stop the pain.

In cases with symptoms simulating hay fever it should be determined if the patient is sensitive to pollens or other proteins before making a diagnosis of ganglion neuralgia.

Another diagnostic point may be found in the appearance of the nasal mucosa about the site of the sphenopalatine foramen. When the ganglion is at fault there is sometimes found a congestion and thickening of the mucous membrane in this region. This appearance is too infrequent to be relied upon as a diagnostic sign.

Another condition to be taken into consideration is that of endocrine imbalance. Headaches of pituitary origin may be greatly benefited by pituitary extract. Pituitary insufficiency may also cause symptoms of hyperæsthetic rhinitis which may be controlled by the use of glandular products. The other endocrine glands must also be considered before definitely making the diagnosis of ganglion neuralgia.

Treatment.—Treatment of sphenopalatine ganglion disturbances consists in the local application to or injection of this nerve-centre, with chemical agents. This should be preceded by a diligent search for the cause of the ganglion disturbance and elimination of the causative factor if possible. In many cases, however, no definite cause of the condition can be found. These are probably due to an irritation or inflammation remaining in the ganglion region after the sphenoiditis or ethmoiditis which originally causes the disturbance has been cured. In these cases application to or injection of the ganglion alone have completely relieved pain.

A completely satisfactory explanation of how a single application of 20 to 40 per cent. cocaine solution to the mucous membrane of the nose overlying the ganglion can permanently cure a ganglion neuralgia has not as yet been made. It has been stated that the effect of the application or injection may in some way bring about an involution of the hyperplastic process surrounding the ganglion. If this be true, although there may be an immediate cessation of symptoms, there is apt to be an interval of several weeks before a permanent cure is obtained.

A number of different chemical agents have been used for application to or injection of the ganglion. The most widely used drug for local application is cocaine, 20 per cent. to a saturated solution. Silver nitrate, from 2 to 75 per cent. and a 0.4 per cent. gaseous solution of formaldehyde have also been used.

For injections of the ganglion, cocaine or procaine solutions are sometimes used but generally either a 5 per cent. phenol in 95 per cent. grain alcohol or absolute alcohol is employed. The addition of the phenol to the alcohol prevents much of the pain experienced in the injection of alcohol alone.

In the treatment of mild cases showing the neuralgic or sympathetic syndrome it has been found that the local applications to the ganglion region in the nose of a 2 per cent. solution of silver nitrate one or two times weekly for from two to four weeks has given permanent relief in some cases. In such cases I prefer to use a 20 per cent. cocaine solution repeated two to three times at three-day intervals. The area in the nose to which the solution is applied is located on the outer wall of the nasal cavity at a point just posterior to and above the attachment to the nasal wall of the posterior end of the middle turbinate. I have obtained better results by a rather brisk rubbing with the applicator at this area rather than simply allowing the applicator to remain quietly in position. Three or four minutes of rubbing should suffice for anæsthetization, but if there is no massaging, the applicator should be left in position for fifteen minutes.

In more severe or long-standing cases of ganglion involvement, more complete and lasting benefit will be obtained by the injection of alcohol into the ganglion. For this purpose from 0.5 to 1 cubic centimetre of alcohol can be used, and if accurately placed within the ganglion substance, should give relief from four months to permanently. If, as is probably the case in most instances, the injection should be in the tissues surrounding the ganglion rather than in the ganglion structure, the relief is apt to be less complete and of shorter duration. In most cases I have found it better to make a series of three injections at intervals of two or three days.

The injection of the ganglion can be made by three different routes: Through the nasal mucous membrane, through the pterygomaxillary fissure, and through the posterior palatine canal. The injection through the nasal mucous membrane was first used by Sluder and for years thereafter was the route commonly employed. Abnormalities in the nose, however, make injecting by this route at times difficult, uncertain and sometimes dangerous.

The method of injection through the pterygomaxillary fissure has been commonly used by dentists. It avoids the possible difficulties of the intranasal route but there is still the uncertainty of exactly placing the solution in the ganglion.

The use of the posterior palatine canal as an injection route was first advocated, in 1921, by Carrea, a dental surgeon of Buenos Aires. He used this route for anæsthetizing the maxillary nerve. Since 1925, this route has been the one of choice for injections of the ganglion because of its features of accessibility, accuracy and certainty of result. However, there were still present certain factors that made it at times difficult, uncertain and occasionally impossible to reach the ganglion by this route. This led me,[2] a few years ago, to make a study of dissected specimens and skulls in an attempt to develop a technic of injection that would attain greater accuracy.

The following technic was adopted by me as the one giving the surest method of approach to the ganglion: First palpate the hard palate in an attempt to find a depression corresponding to the location of the foramen. If this cannot be felt, the needle is inserted first so that the shaft comes opposite the anterior edge of the first molar tooth, close up to the alveolar edge, pressing the needle upward and slightly backward at an angle of about 45°. If the needle does not enter the canal it is removed and inserted again a millimetre or two directly posterior to the first insertion. In this way it may be necessary to insert the needle several times, but if the palate has been previously rubbed with a 10 per cent. cocaine solution and painted with an antiseptic solution, it causes no pain and gives very little chance for infection. When the molar teeth are absent the posterior edge of the hard palate and especially the posterior end of the pterygoid process should be palpated and the needle first inserted about two centimetres anterior to the edge of the pterygoid process. The point of the needle should be inserted to a depth of 3.3 to 3.8 centimetres, being directed somewhat internally to slide up along the inner wall of the canal. To prevent as far as possible the pain of an alcoholic injection, it is wise as a preliminary measure to massage the ganglion region in the nose for a few minutes with a 10 to 20 per cent. cocaine solution. Before making an injection, an estimate of the size of the skull should be made. If the skull appears to be smaller than the average, the needle should be inserted to a lesser depth, and if the skull is large, the point of the needle should be carried to a greater depth. In spite of the most skillful technic there is occasionally found a patient in whom an injection of the ganglion by this route cannot be made, due to extreme narrowness of the canal or a tortuosity that would prevent the entrance of the needle. In such cases injection by one of the other two routes will be necessary. In rare instances it may be found wise or necessary to attempt an extirpation of the ganglion. Frazier[3] in 1921, described a surgical approach to the ganglion that would appear to give satisfactory results in the hands of the experienced and skillful surgeon.

Prognosis and Complications.—The prognosis in treating cases of spheno-

palatine ganglion neuroses is very uncertain. A larger proportion of improvement is obtained in the sympathetic than in the neuralgic type.

When symptoms are typical of ganglion involvement much can be promised as a result of treatment, but the typical case is rare. The great majority of patients are among those cases of atypical neuralgia which are but little benefited by any one procedure of treatment. The typical neuralgic symptom-complex can usually be relieved by the application of cocaine to the ganglion region in the nose. If this is found to give some relief, a series of alcoholic injections are apt to give excellent results. Patients that show no improvement after three alcoholic injections can probably be considered hopeless so far as that method of treatment is concerned.

Some cases are not relieved by local applications but are relieved or cured by alcoholic injections. Others seem to be relieved for some time and then recur. In the latter case re-injections are indicated. Sometimes a failure to establish a lasting cure is due to the failure to follow up the injections with the proper surgical procedure to remove the cause of the condition primarily such as sinusitis, or to correct an imbalance in the endocrine system.

Probably the most frequent complication that may follow the attempt to inject the sphenopalatine ganglion is the escape of the alcoholic solution down the pharyngeal wall into the throat or larynx. This would give an unpleasant but not dangerous experience. Sometimes a temporary swelling and ecchymosis in the cellular tissue beneath the lower eyelid has occured, causing the eye to close. Swelling and pain in the temporal and parietal regions of the head are common and transient following the injection. Excruciating pain in the head is sometimes experienced which may last for several days and require sedatives. Primary hæmorrhage has occurred rarely, probably due to the penetration of the internal maxillary artery. Secondary hæmorrhage is somewhat more common, coming on five or six days after the injection. This is probably due to the erosion by the alcohol of the sphenopalatine or descending palatine arteries. A few cases of paresis of the abducens nerve have been reported, causing a diplopia. This occurs shortly after the injection and is due to the passage of the injecting fluid through the sphenomaxillary fissure into the orbital tissues. In these cases the paresis and diplopia have cleared up within a few weeks. It seems possible also for blindness to occur if the injected alcohol reaches the optic nerve but this nerve is well out of reach, unless the needle is inserted to an unwarranted depth.

Cases of neuralgia for treatment by injection of the sphenopalatine ganglion should be selected with care. Injection of all atypical neuralgias is apt to bring discredit on a therapeutic procedure that does have a limited field of usefulness. In typical conditions of ganglion neurosis brilliant results can be obtained but in the majority of neuralgic cases little should be promised. However, in many cases, it seems perfectly justifiable to employ this procedure for the purpose of eliminating the ganglion as a source of the neuralgic condition present. If there is failure to relieve the pain other methods of therapeusis may give the desired results.

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NON-SURGICAL CAUSES OF ACUTE ABDOMINAL PAIN

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The simulation of an acute surgical lesion in the abdomen by a medical condition is not uncommon. Tabes dorsalis, plumbism, herpes zoster, spondylitis, and coronary occlusion are examples of common medical conditions which not infrequently present abdominal symptoms closely resembling those of acute appendicitis, ruptured ulcer, or calculous cholecystitis. The abdomen has repeatedly been opened and no pathological lesion found, while, at a later date, laboratory evidence of diabetic acidosis or of plumbism was returned. The surgeon or internist must be alert to the possibilities applying to his particular case before subjecting a patient with atypical abdominal findings to an unnecessary exploratory laparotomy. Practically no abdominal condition is such an emergency as to preclude a white blood count and urinalysis (sugar, albumin, and microscopical).

A classification of the medical conditions causing acute abdominal pain, which may, on occasions, be confused with surgical entities, is presented below. Such a list is not all inclusive, nor does it contain those conditions which usually lead to surgical intervention at a later date (*e.g.*, stone in the genito-urinary tract, biliary colic, *etc.*).

Non-surgical Causes of Acute Abdominal Pain:

(1) Metabolic
  (a) Diabetic acidosis.
  (b) Tetany.

(2) Cardiovascular
  (a) Referred from the heart (angina pectoris, coronary occlusion, pericarditis).
  (b) Embolism and thrombosis (mesenteric occlusion, subacute bacterial endocarditis, polycythemia).
  (c) Intra-abdominal arterial disease (periarteritis nodosa, dissecting aneurism, abdominal angina).

(3) Hæmatologic
  (a) Hæmolytic icterus.
  (b) Purpura (Henoch, Osler).
  (c) Sickle-cell anæmia.
  (d) Splenic enlargements with perisplenitis or infarction (leukemia, Banti's disease, Hodgkin's disease, *etc.*).

(4) Infectious
  (a) Occasionally at onset of acute infections (influenza, typhoid and paratyphoid fevers, poliomyelitis, malaria, acute tonsillitis).

(b) Dysentery (amœbic, bacillary).
(c) Rheumatic peritonitis.
(d) Tabetic crises.
(e) Arachnoidism.

(5) Gastro-intestinal
(a) Cholangitis.
(b) Acute gastro-enteritis (foods, heavy metals, acids, alkalis, *etc.*).
(c) Pylorospasm.
(d) Intestinal parasites.

(6) Genito-urinary
(a) Dietl's crises.
(b) Pyelitis.
(c) Distended urinary bladder.

(7) Pulmonary
(a) Pleurisy.
(b) Pneumonia in children.

(8) Abdominal-wall disorders
(a) Early herpes zoster.
(b) Intercostal neuralgia.
(c) Trichiniasis.
(d) Trauma.

(9) Hysteria and malingering

METABOLIC.—Acidosis is not infrequently associated with acute abdominal distress resembling the picture of acute appendicitis. In differentiating these two conditions symptomatically, a finding of importance is the fact that in diabetic acidosis the vomiting usually precedes the occurrence of abdominal pain, while in appendicitis the reverse is usually the case. Both diabetic acidosis and acute appendicitis may exhibit abdominal pain, fever, and leucocytosis. A white blood count of 25,000 or more is common in acidosis. Rabinowitch[1] states that in children, particularly, it may reach 75,000 or more. If there is a definite intra-abdominal lesion present causing pain, it will persist or increase in spite of treatment for the acidosis. Acute appendicitis and diabetic acidosis may, of course, occur together; the safest procedure under such circumstances is to institute insulin therapy and operate at once. An example of the simulation of acute appendicitis by diabetic acidosis is seen in the following case:

CASE I.—A fifteen-year-old Jewish girl was admitted to the surgical service of the University Hospital with a diagnosis of acute appendicitis. The history was that at 2 A.M. of the day of admission the patient was awakened by a diffuse pulmonary pain and a feeling of constriction in the chest. Following a bowel movement, the pain seemed to migrate from the chest and settle in the abdomen. The abdominal distress was quite severe from its onset. She was nauseated and vomited twice. On admission to the hospital that evening, there was considerable nausea, and severe pain in the right lower quadrant of the abdomen.

Physical examination revealed a T.P.R. of 100.4°, 160, 36. The patient seemed to be acutely ill, but was quite well nourished. Examination of the heart and lungs was negative; the abdomen presented a generalized rigidity, somewhat more marked on the right

side, together with right lower quadrant tenderness. Peristaltic sounds were somewhat less than normal. Liver, spleen, and kidneys were not palpable.

A tentative diagnosis of acute appendicitis was made. Laboratory data revealed a white blood count of 26,000, 91 per cent. of which were neutrophiles. Red blood count was 5,400,000 per cubic millimetres and hæmoglobin was 110 per cent. Urinalysis showed a trace of albumin, and four plus sugar, acetone, and diacetic acid. The patient was transferred to the medical wards with a diagnosis of diabetic acidosis. At this time, additional careful questioning of the family revealed a history of recent loss of appetite and weight.

Within several hours after the institution of a diabetic régime, the abdominal distress had entirely disappeared. It is noteworthy that the white blood count twenty-four hours after admission was 24,000, and seventy-two hours later, 15,400; five days after admission the white blood count had returned to normal, and the false polycythemia of dehydration had disappeared, the red cells dropping to 4,400,000 and the hæmoglobin to 78 per cent. The patient pursued an uneventful convalescence and left the hospital with her diabetic state well regulated, and free of any abdominal distress.

The occurrence of abdominal pain and distress in tetany is not well recognized. The condition is infrequent, but must be borne in mind. Abdominal pain and rigidity have been so pronounced in tetany as to lead to operative intervention for a suspected ruptured ulcer.[2] The following patient with abdominal pain resulting from tetany was seen in the medical wards:

Case II.—D. M., an Italian male of thirty-eight years, was admitted to the surgical wards of the University Hospital with a diagnosis of duodenal ulcer, with possible perforation. The patient's history contained periods of diarrhœa during childhood, a progressive weakness for the past three years, and abdominal pains for one and a half years. These were in the nature of hunger sensations localized just beneath the lower end of the sternum. For the six months previous to admission there were periods of relief from pain, each lasting one to two weeks. Food at times gave marked relief; soda was never tried. Fried foods or meats aggravated this distress. There was no pyrosis, nausea, vomiting, or hæmatemesis. The patient had lost 12 per cent. of his weight in the past three years. The only additional symptom was a sensation of pins and needles in the extremities.

Physical examination revealed no abnormalities. Liver, kidneys, and spleen were not palpable. The epigastrium was moderately tender, and a slight amount of rigidity was noted. Following subsidence of the acute symptoms, gastro-intestinal X-ray revealed a peculiar pooling throughout the small intestine, with marked dilatation of the jejunum and probably most of the ileum, plus loss of the valvulæ conniventes in the jejunum; many fluid levels were noted. Dr. Henry K. Pancoast reported that he had never before seen a similar picture.

The patient was transferred to the medical wards, where it was accidentally discovered, during a blood-pressure estimation, that the patient's hand assumed an obstetrical position. A blood calcium estimation was 6 milligrams per cent. All of the other characteristic signs of tetany were then found. A diagnosis of chronic idiopathic adult tetany was made. Marked subjective and objective improvement followed administration of large doses of calcium orally.

Cardiovascular.—The frequent causation of abdominal symptoms by cardiac pathology is well known. The occurrence of severe pain, limited to the epigastrium, due to coronary occlusion, is with difficulty at times differentiated from an upper abdominal catastrophe. The introduction of the direct anteroposterior chest leads[3] in the electrocardiogram has been of much assistance under such circumstances. Abdominal operations have been performed because of the simulation of acute appendicitis or an acute surgical condition

of the kidney or gall-bladder by periarteritis nodosa.[4] Klein and Owen[5] emphasize the great variability of symptoms, with the most common being a septic fever, polyneuritis, polymyositis, hæmaturia or nephritis, abdominal cramp-like pains, and progressive emaciation. The gastro-intestinal symptoms may include cramps, colic, sensitivity to palpation of the abdomen, signs of peritoneal irritation, loss of appetite, vomiting, diarrhœa or constipation, and bleeding from the gastro-intestinal tract. Acute abdominal distress is not uncommon in subacute bacterial endocarditis. Sharp left upper quadrant pain during the course of this disease may follow splenic infarction with the subsequent development of perisplenitis, producing a definite friction rub. Small infarcts may occur throughout the intestinal tract, producing occult, or, at times, visible blood in the stools. The simulation of an acute surgical condition in the abdomen by a hemopericardium is recorded below.

Case III.—C. H., a white male of fifty-one years, was admitted to the surgical wards of the University Hospital with a diagnosis of ruptured duodenal ulcer with terminal peritonitis. The patient had complained of slight abdominal discomfort for several days previous to the onset of an intense epigastric pain. On examination, the upper abdomen presented a board-like rigidity with extreme tenderness throughout. However, the cervical veins were quite dilated, the lips and fingertips cyanotic, and the heart sounds quite distant. X-ray revealed a huge pericardial effusion, which was tapped, 900 cubic centimetres of almost pure blood being removed at the first tapping, and 600 cubic centimetres several days later, with almost immediate relief of symptoms. When relaxed, the upper abdominal rigidity proved to be a hugely distended liver. The patient made an uneventful recovery and is well two years following the incident.

Hematologic.—A sense of weight or of dragging abdominal pain is often the first sign of an enlarged spleen in leukæmia, Banti's disease, Hodgkin's disease, amyloidosis, or late lues. The development of a perisplenitis or infarct in any of these conditions may lead to acute upper abdominal pain. The enlarged spleen is sometimes painful and sensitive to pressure, and may be associated with spasm of the overlying muscles. Attacks of abdominal pain in hæmolytic icterus are attributed to crises of deglobulization; it must, however, be remembered that cholelithiasis occurs in over half of these cases.

Periodic crises of severe abdominal pain simulating surgical conditions have been reported in sickle-cell anæmia.[6] These are general or local in character and are usually accompanied by fever. The following case, illustrating this condition, was seen in the medical wards:

Case IV.—H. C., aged twenty-one years, a colored female, was admitted with a chief complaint of aching bilateral lower abdominal pain. Since her marriage two years previously, the patient noticed this discomfort for the first two days of each menstrual period. Four days after the onset of her last period, the patient had a very severe attack of pain and was sent to the hospital. For the last several years the patient had lacked vigor and had tired quite easily. She had lost 15 per cent. of her body weight in this period. There had been some dyspnœa on exertion and slight ankle œdema for the past year. For the past two months a small traumatic ulcer had persisted on the left ankle.

Physical examination (T.P.R. 98°, 110, 28) revealed a fairly well-developed colored girl, with a distended abdomen and marked abdominal rigidity. A surgical consultation offered the diagnosis of pelvic inflammatory disease, with a suggestion that palliative treatment be followed. Gynecological consultant found no pelvic pathology. The fol-

lowing day, the temperature rose to 101°, and remained between 99.5° and 102.5° for a week. Complete blood count was as follows: red blood-cells, 3,800,000; white blood-cells, 26,000; haemoglobin, 60 per cent.; neutrophiles, 81 per cent.; lymphocytes, 6 per cent.; monocytes, 7 per cent.; eosinophiles, 4 per cent., and myelocytes, 2 per cent. Marked sickling of the red blood-cells was seen by the appropriate preparation. Van den Bergh reaction showed a delayed direct and an indirect reading of 2.1 units. Urinalysis and blood Wassermann reactions were negative. Cell volume index was 0.96; fragility test, platelets, and reticulocytes were normal. A diagnosis of sickle-cell anæmia was made. Gastro-intestinal studies proved to be entirely negative.

Severe abdominal pain may occur in purpura, as described by Henoch, and is sometimes associated with allergic skin eruptions. In describing this latter group, Osler[7] reported twenty-nine cases in which there were purpuric manifestations together with colicky abdominal pain. The skin manifestations included purpura, urticaria, angioneurotic œdema, and erythema. Fifty per cent. of the cases had fever, and practically all had severe colicky abdominal pain. A case falling into this group was recently diagnosed in the University Hospital by Dr. O. H. Perry Pepper, and is reported below.

CASE V.—A. M., a white male aged thirty-one years, was admitted to the medical wards of the University Hospital complaining of terrific left-sided abdominal pain. The onset of the patient's illness dated back one year. At that time, an abrupt severe abdominal pain caused the patient to double up. There was no nausea or vomiting. The pain was confined to a small area just to the left of the umbilicus, and did not radiate. The pain was present constantly for ten days. The patient noticed that his skin appeared "green" and that his urine assumed a red or black color. A physician found albumin and blood in the urine. At the end of ten days the pain and jaundice abruptly disappeared. Four or five such attacks occurred at intervals during the year before admission. The only additional positive fact in the history was the occurrence of an urticaria which was usually coincident with the attacks of abdominal pain.

Physical examination revealed many urticarial wheals over the skin of the chest. There was marked tenderness just above and to the left of the umbilicus with no hyperesthesia. There was no costovertebral tenderness. Moderate rigidity was observed in the left upper abdomen.

Blood count showed a moderate secondary anæmia with a slight neutrophilic leucocytosis. Urine contained an abundant amount of albumin, with many granular and hyaline casts. Phenolsulphonephthalein showed an elimination of 50 per cent. of the dye in two hours. Blood urea nitrogen was 21 milligrams per cent. Van den Bergh was normal. Gastric analysis showed a slight excess of free and total acid. Biliary drainage revealed many calcium billirubinate crystals. Complete blood studies disclosed the following: reticulocytes, 15 per cent.; clot retraction, normal; venous coagulation time, thirty-seven minutes; cell volume index, 0.96; fragility test, normal; platelets, 64,000. Blood and spinal fluid Wassermann tests were negative. Later examinations revealed an increasing degree of secondary anæmia and a hæmaturia.

An intravenous urogram showed perfectly functioning and seemingly normal kidneys. Urea clearance was 43 per cent. of average normal function. Cystoscopy was negative, and ureteral dilatation failed to reproduce the pain. A flat plate of the abdomen was negative. Examination of the urine for tubercle bacilli and guinea-pig inoculation were negative. Blood cultures were negative.

During his stay in the hospital, the patient's temperature varied between 100° and 102°, with a commensurate elevation of the pulse. The patient died shortly after admission. Autopsy showed cloudy swelling of the kidneys with submucous hæmorrhages of the renal pelves, multiple cerebral hæmorrhages, some fatty degeneration of the liver, follicular splenitis, and a negative bladder, prostate, and ureters.

INFECTIONS.—It is beyond the scope of this short discussion to detail the abdominal picture in acute infections. However, the onset of many acute infectious diseases is often accompanied by severe abdominal distress and occasionally by nausea and vomiting. It must also be remembered that a surgical emergency, as appendicitis, may occur during the course of an acute infection (*e.g.*, tonsillitis). Acute rheumatic fever is of especial importance in this connection because acute abdominal pain and signs of peritoneal irritation may appear during the course of an attack. The general reaction is severe with a high fever and leucocytosis, and the abdominal phenomena are often more diffuse than in appendicitis. Localization to the right lower quadrant is less apt to occur. If operation is performed, one may find clear fluid in the abdomen and hyperæmia, œdema, and infiltration of the peritoneal and subperitoneal tissues.[8]

In tropical regions, acute abdominal malaria has been confused with surgical abdominal catastrophes. Taylor[9] has pointed out that although nausea, vomiting, abdominal pain, and fever are not uncommon in abdominal malaria, distinguishing the latter from acute surgical conditions of the abdomen rests principally upon the absence of abdominal rigidity and a positive test for occult blood in the vomitus or gastric contents.

Arachnoidism, or disease due to poisonous spider bites, is becoming increasingly more frequent. Numerous surgeons have subjected patients to the additional trauma of a major surgical operation because of faulty diagnosis and confusion with acute surgical conditions.[10] Muscle pains, beginning in the region of the bite, rapidly spread throughout the body, and are usually felt most intensely in the abdominal muscles. Rigidity and muscle spasm may become so marked that the abdomen is actually board-like. This rigidity is not confined, however, to the muscles of the abdomen, and true local tenderness is usually absent.

Acute anterior poliomyelitis in children is not infrequently associated with acute abdominal pain, nausea and vomiting, so that the clinical picture has been mistaken for acute appendicitis. The recent outbreak of amœbiasis (amœbic dysentery) has led to occasional unfortunate laparotomies because of faulty diagnosis. This disease may be so mild that vague abdominal pain and indigestion may be the only symptoms for months. In other cases, there may be sudden colicky abdominal pain with abdominal tenderness and fever (100°–102°). Apart from the presence of amœbæ, the stools are not characteristic. Absolute diagnosis can be made only by recognizing the motile amœbæ or their cysts in the stool; typical organisms are most often found in preparations made from material taken directly from the bowel ulcerations through a sigmoidoscope.

GASTRO-INTESTINAL.—Most of the conditions enumerated above under this heading are easily recognized. The vomiting and crampy abdominal pains sometimes seen in trichiniasis may simulate a surgical abdomen. The pains are often due to encysted larvæ in the abdominal muscles or diaphragm. A gastroenteritis may occur immediately following the consumption of pork infested with the trichinæ; in most instances, however, there is an incubation

period of from five to twenty days. The onset is usually sudden, and intestinal hæmorrhage has been noted occasionally.

Severe localized or general abdominal pain may be incident to metallic poisonings; abdominal rigidity is also usually a feature. In these cases, a history of poisoning is usually available. More difficult to distinguish from a surgical lesion are the severe, crampy, peri-umbilical pains which may occur in plumbism, sometimes many months after all exposure to lead has ceased.

CONCLUSIONS

Accurate diagnosis of pathological conditions of any abdominal organ is in most instances not possible from the pain alone. This follows in part from the fact that the abdominal organs themselves are devoid of pain sensations, and that pain caused by disease of them is usually propagated to an area other than that in which it is produced. The coverings of the abdominal organs, their ducts and blood-vessels can, however, give rise to pain sensations.

The examination of the blood, urine, and often of the fæces, together with the temperature, pulse, and respiratory rate, are important factors in determining the etiology of abdominal pain. Pain as an isolated symptom is not a reliable diagnostic criterion, but becomes quite valuable in association with other findings.

SUMMARY

(1) A classification of some of the non-surgical causes of acute abdominal pain has been attempted.

(2) Case reports illustrating several of the more uncommon of these are included.

(3) The abdominal pictures of some of the less well known are briefly reviewed.

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THE "PUSH-BACK OPERATION" IN CLEFT-PALATE SURGERY

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of Philadelphia, Pa.

The primary purpose of any cleft-palate operation is to repair the split palate and to correct the speech defect. The latter can only be accomplished by placing the "palatopharyngeal-sphincter" in or close to its normal position. From the patient's standpoint any operation on the palate is judged by the improvement or lack of improvement in his speech. The secret of obtaining good speech in cleft-palate patients is to establish complete velopharyngeal closure. This can only be obtained by an operation which will permit the velum to come in contact with the pharyngeal wall and allow the "palatopharyngeal-sphincter" to shut off the nasopharynx.

The palate in man varies considerably in length without interfering with normal speech; yet there are limits above or below which normal speech becomes impossible. A study of the speech obtained after successful cleft-palate operations reveals the fact that its deviation from normal is almost directly proportionate to the shortness of the palate. The greater the efficiency of this closure the more satisfactory the speech. In other words, insufficiency of velopharyngeal closure is due to an abnormal distance between the velum and pharyngeal wall when the "palatopharyngeal-sphincter" is contracted.

In short palate (Fig. 1*), the palatal insertion of the superior constrictor and levator palati muscles are located farther forward than in the normal palate. A considerable number of cleft-palate patients have a short palate.

Individuals with cleft velum alone, and patients with a cleft which extends as far forward as the junction of the middle third with the anterior third of the hard palate have shorter palates than those with lip-jaw-palate splits. A study of our own post-operative follow-up, and cases consulting us after having been operated upon by competent surgeons have convinced us that where no shortening of the velum exists good operative and functional results may be obtained when successful closure of the cleft palate has been accomplished.

The purpose of this paper hinges on the last paragraph. We have been misunderstood as saying that all cleft-palate cases should have the "push-back operation." Just why this impression has gained credence, we cannot understand. We have never made such a claim because we do not believe this to be the fact.

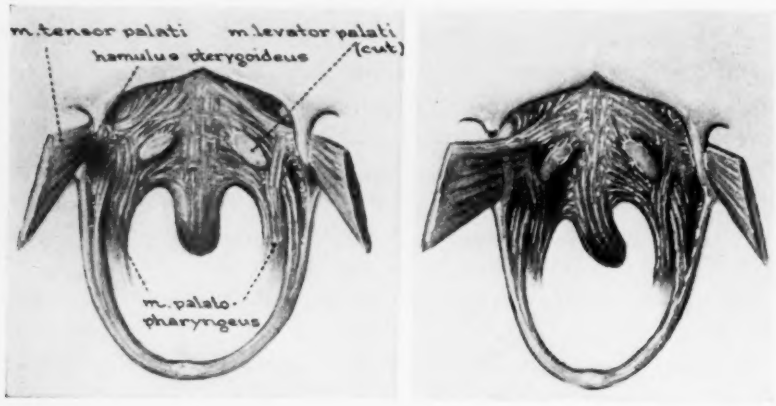
We do not use the "push-back operation" in cases in which we can obtain velopharyngeal closure by the methods generally employed, such as the von Langenbeck operation or any of its modifications.

* The illustrations in this article were also used in "The Operative Story of Cleft Palate" by Dr. George M. Dorrance, published by W. B. Saunders Company.

We do believe that the "push-back operation" has a distinct place in cleft-palate surgery and we will show the cases in which it is indicated.

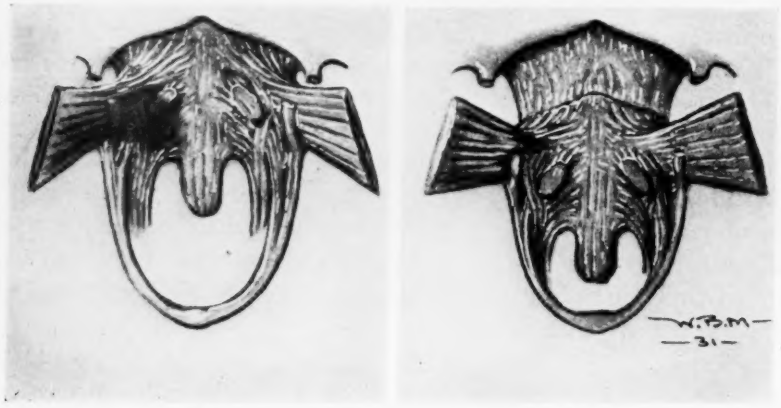
Since success in cleft-palate surgery is largely dependent on velopharyngeal closure, we will review the salient points on this subject.

Velopharyngeal closure is accomplished by the "palatopharyngeal-sphincter" situated in the lower part of the nasopharynx. When it contracts,



A B

A, Dissection of the pharynx in a congenitally short palate. B, Division of one hamular process removes tension of tensor palati muscle in a case of congenital shortening of the palate.



A B

FIG. 1.—A, Note how division of both hamular processes removes all tension of tensor palati muscles, and places palatal insertion of the superior constrictor muscle in desired position to close the nasopharynx. B, Backward displacement of the palate with division of the hamular processes restores "palatopharyngeal-sphincter" in cases afflicted with congenital shortening of the palate.

it shuts off the nasopharynx from the oropharynx. The "palatopharyngeal-sphincter" is a definite sphincter muscle which produces circular contraction of the nasopharynx (Fig. 2). This sphincter is a muscular ring formed by the pterygopharyngeal portion of the superior constrictor muscle which inserts in the palatal aponeurosis at the site of insertion of the levator palati muscles.

The closure of this sphincter is complete during the formation of the non-nasal letter sound "ah" made with the mouth wide open.

The structures concerned in causing this closure are the lowermost portion of the nasopharyngeal wall on one side and the velum on the other (Fig. 3). The portion of the nasopharyngeal wall which enters into this mechanism is formed by the pterygopharyngeal portion of the superior constrictor muscle which on contraction constitutes what is usually referred to as Passavant's cushion. The velum from the standpoint of function is divided into two parts, an anterior horizontal portion made up essentially of muscle tissue and a

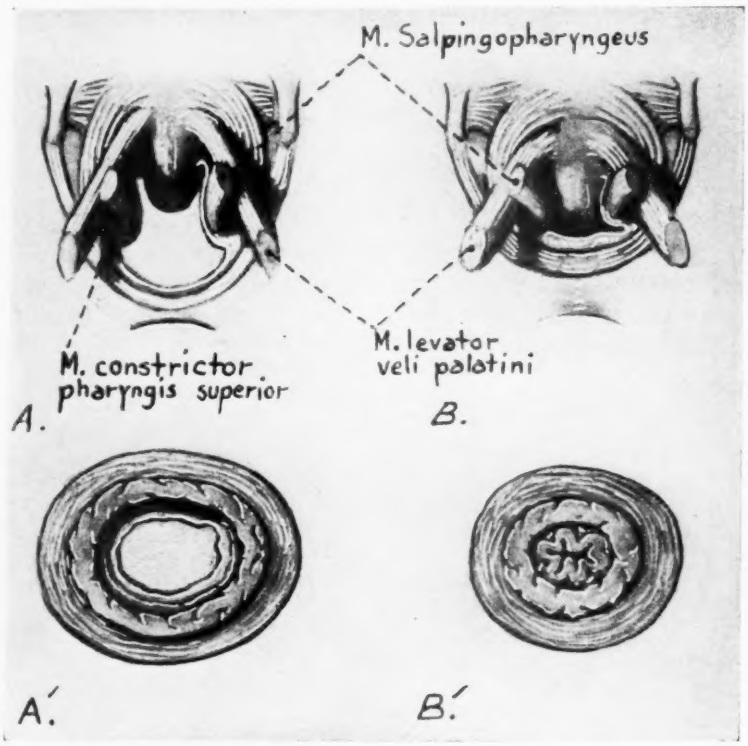


FIG. 2.—Artist's drawing of the "palatopharyngeal sphincter." *A*, Shows the sphincter open while *B* depicts it when closed. *A'*, Shows the pylorus open while *B'* depicts the pylorus closed.

posterior vertical portion which hangs down from the former (Fig. 4). This latter segment is formed almost entirely by the uvula. At the junction of these two portions, there is an interlacing of the palatal muscles. It is at this site that the levator palati muscles are blended and attached to the palatal aponeurosis (Fig. 5). They raise the velum upward and backward. The nasal aspect of this portion of the velum which corresponds with the attachment of the levator palati muscles approximates Passavant's cushion during velopharyngeal closure and forms the anterior segment of this mechanism. At rest, the uvula hangs down as a curtain. As it contracts and ascends slightly

on velopharyngeal closure, it makes the vertical and dependent portion of the velum shorter. This causes the velal segment to become broader and thicker at the site of insertion of the levators.

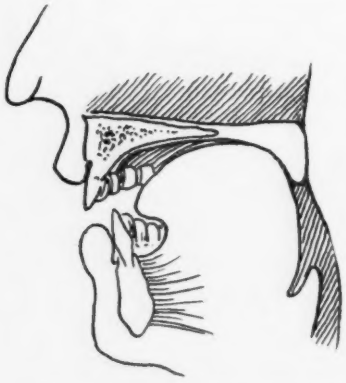


FIG. 3.—Sketch showing how normal velopharyngeal closure occurs. Note the forward movement of the posterior pharyngeal wall manifest by bulging of Passavant's cushion. The vertical portion of the velum is shown to assist in the sphincteric closure.

The elevation of the pharynx brings these muscles into proper position enabling them to close the communication between the oral and nasal portions of the pharynx. To recapitulate, the elevator muscles of the pharynx pull the relaxed muscles upward and forward while the lateral walls approach the mid-line. The velum is brought upward and backward by contraction of the levator palati muscles. The pterygopharyngeal portion of the superior constrictor muscles produces, by its contraction, the sphincteric closure of the nasopharynx (Fig. 6).

In cleft palate the anterior segment of the muscle forming the pharyngeal ring is split and the separated ends are far apart (Fig. 7). The cleft velum assumes the shape of a horseshoe with the opening directed backward. The borders of the defect in this case take the shape of one side

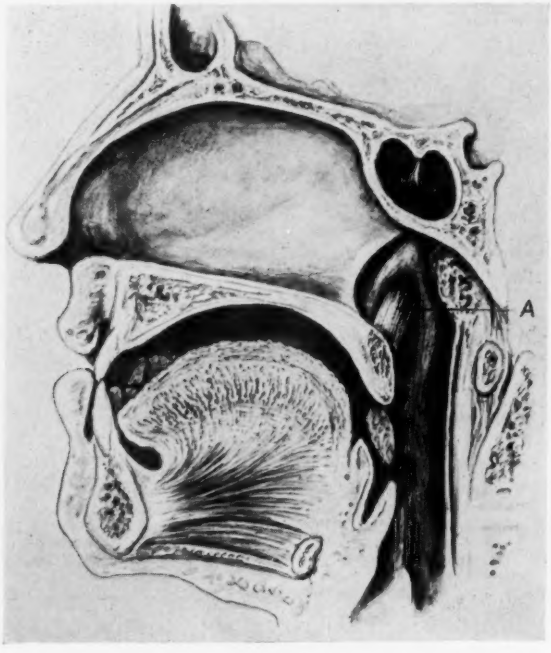


FIG. 4.—Frozen sagittal section with the levator palati muscle dissected—A.

of the horseshoe with the convexity directed away from the median line. The tensor palati muscle is shorter in cleft-palate cases than in normal individuals.

The independent pull exerted on each side by this shortened muscle drags each half of the cleft velum forward and outward and causes the tips of the cleft uvula to point toward the median line. Each half of the cleft palate is continuous with the corresponding arm of the cleft pharyngeal ring. The shortening of each half of the velum just mentioned tends to drag the corresponding arm of the pharyngeal ring forward and outward, thereby flattening it on each side and increasing the diameter of the nasopharynx in all directions. The cleft superior constrictor muscle of the pharynx is thereby unable to pro-

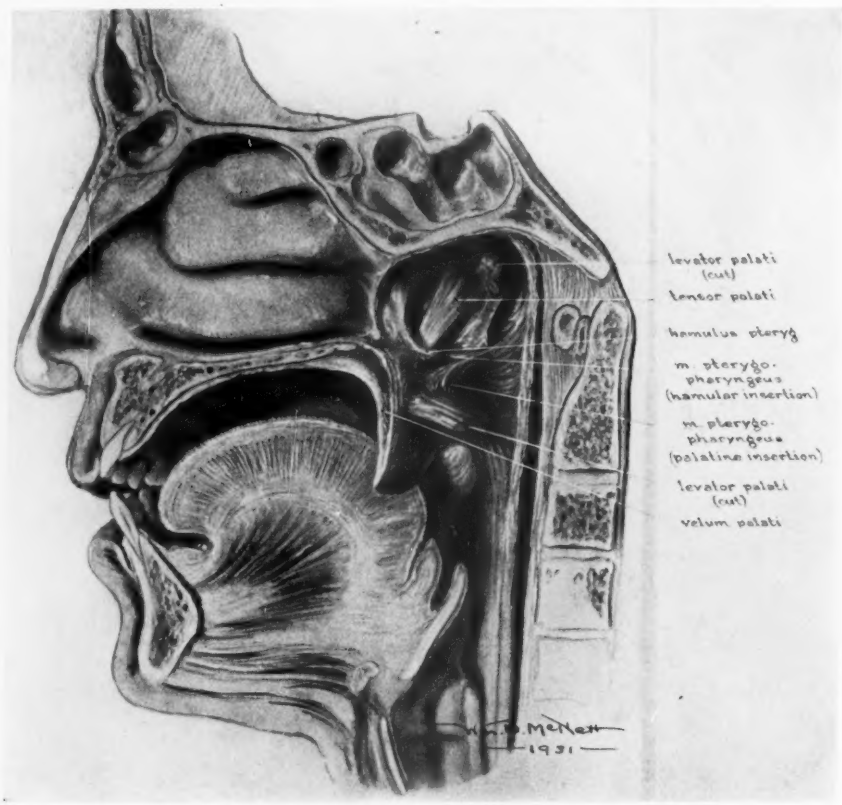


FIG. 5.—Sagittal section of the head to show the lateral wall of the pharynx. Note the two slips of insertion for the pterygopharyngeal portion of the superior constrictor muscle of the pharynx.

duce the necessary sphincteric closure between the oropharynx and the nasopharynx (Fig. 8).

Division of the hamular process releases the tension produced by the tensor palati muscle and permits mesial displacement of the palatal insertion of the superior constrictor muscle of the pharynx. This also displaces inward and backward that portion of the pterygopharyngeus which inserts into the hamulus, thereby reducing the abnormally increased diameter of the nasopharynx. The function of the tensor palati muscle is also altered from that of a tensor to that of an elevator, thus augmenting the function of the levator palati muscle. By this means lateral tension is removed and the anterior ends

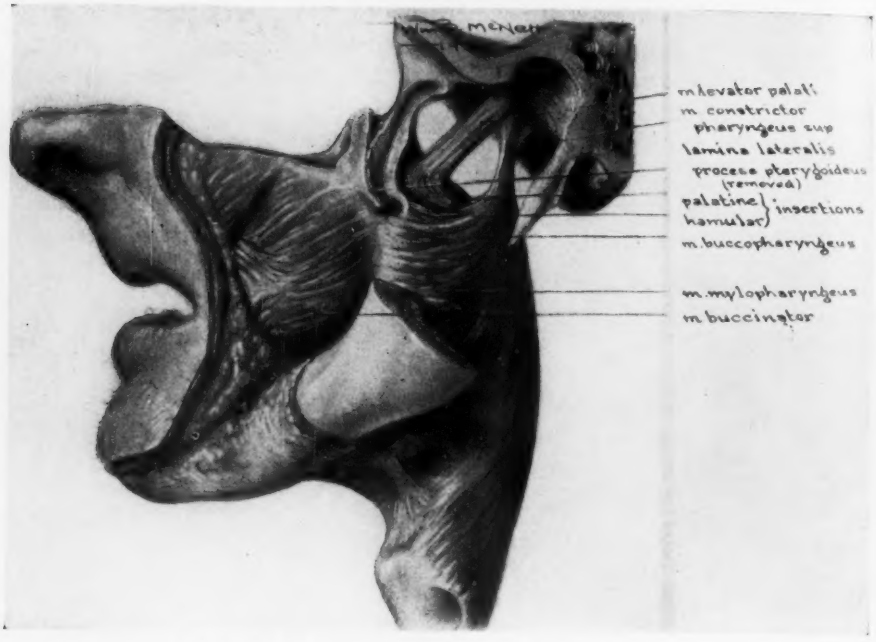


FIG. 6.—Lateral view of a dissection of the pharynx, showing the palatal and the pterygoid insertions of the pterygopharyngeus muscle. The lateral pterygoid plate and the tensor palati muscle have been removed.

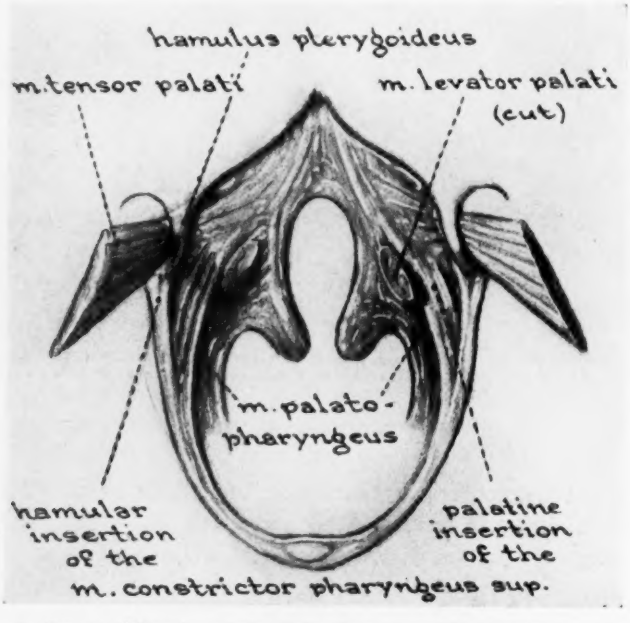
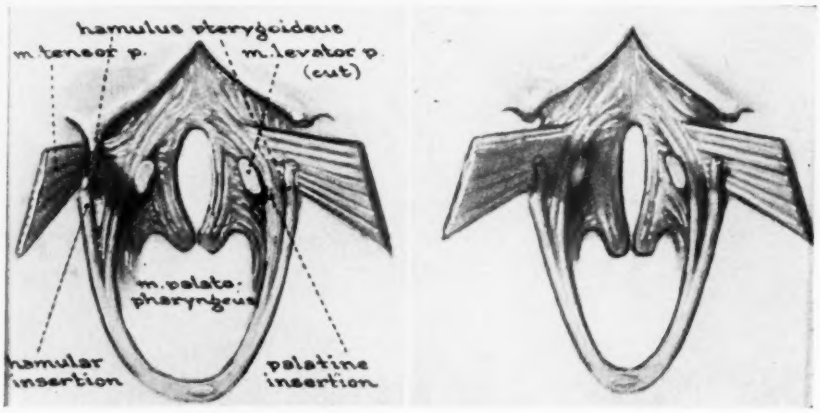


FIG. 7.—Dissection of the cleft velum in a child about two years old to show the split pharyngeal ring. Note the palatal insertion of the superior constrictor muscle of the pharynx. Each half of the split velum is shortened by outward and forward pull of the tensor palati muscle.

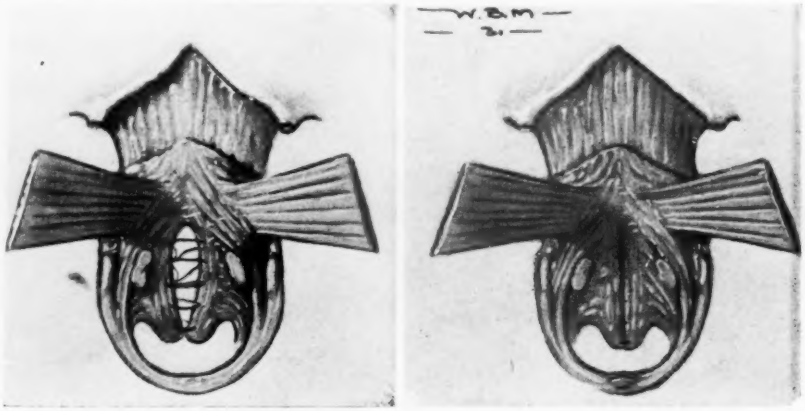
of the cleft pharyngeal ring can be approximated at the mid-line, thus restoring the divided "palatopharyngeal-sphincter."

Restitution of the anterior continuity of the superior constrictor muscle of the pharynx cannot restore proper function in cleft-palate patients when the palate is short. This explains why the so-called von Langenbeck operation fails to restore function in cases of short palate (Fig. 9).



A B

A, Division of the hamulus on one side removes tension of tensor palati muscle in a case of cleft velum. B, Division of hamulus on both sides removes tension of tensor palati muscles in a case with split velum and places palatal insertion of superior constrictor muscle in desired position to close nasopharynx.



A B

FIG. 8.—A, Note how backward displacement of palate with division of hamular processes restores "palatopharyngeal-sphincter" in cases afflicted with split velum. B, Note how the "palatopharyngeal-sphincter" is restored when the sutures are applied in the "push-back operation" performed in cases with cleft velum.

Closing the split palate by mesially displacing the soft tissue covering the palatal vault is the cornerstone of cleft-palate surgery because all conservative surgical methods for repairing the palate are based on this principle. This procedure was codified by von Langenbeck, after whom the operation is named. The modifications and the improvements added from time to time to

FIG. 9.—Artist's drawing of a cleft velum in a child about two years old.

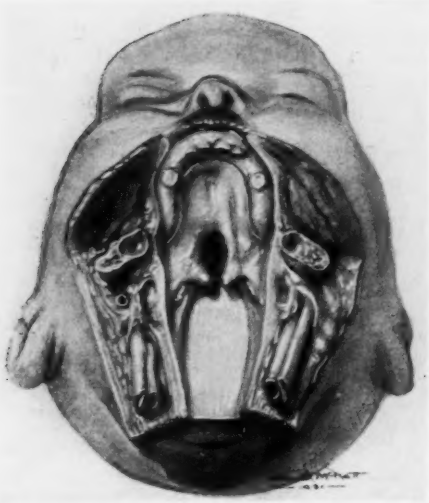


FIG. 10.—Shows the relaxation incision applied in the first stage of the "push-back operation."

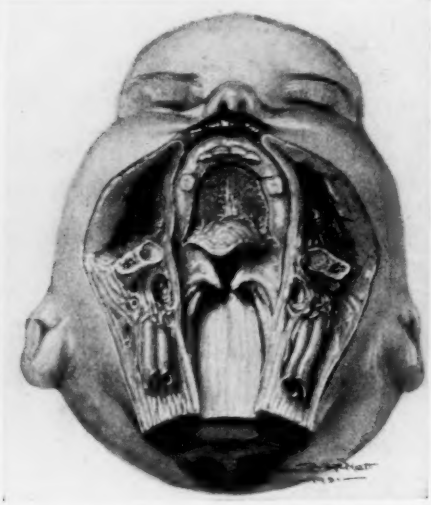


FIG. 11.—Shows how the palatal mucoperiosteum is raised from the underlying bone all the way back to the attachment of the palatal aponeurosis.

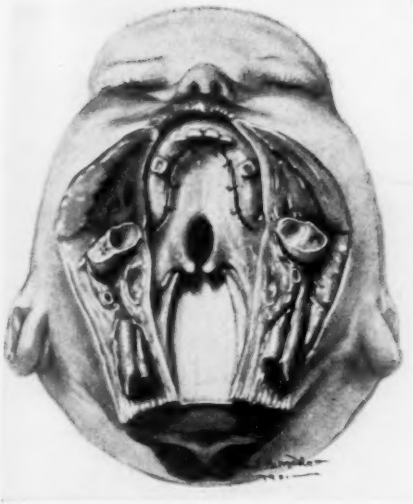


FIG. 12.—Shows the end of the first stage in a "push-back operation" performed for a cleft velum. The raised palatal mucoperiosteum is held in position with silk sutures.

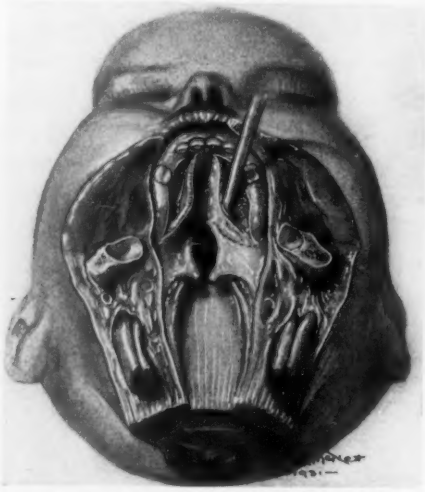


FIG. 13.—Shows how the palatal mucoperiosteum is elevated when lateral incisions are applied.

FIG. 14.—Shows the second stage of the "push-back operation." The palatal mucoperiosteum has been completely freed from the underlying bone and the nasal mucosa divided from its connection with the posterior border of the hard palate. The hamular processes are also sectioned above their connection with the mesial pterygoid plates.

this method by Billroth, Ehrmann, Wolff, Berry, Addison, Veau and other cleft-palate pioneers failed to take into account our present conception of the function of the "palatopharyngeal-sphincter" and its rôle in cleft-palate surgery when a shortened palate is present.

In the majority of our cleft-palate operations including the "push-back operation," we use the multi-stage procedure in which two or more distinct operations are performed at separate sittings allowing an interval of time to elapse between the stages so as to permit the collateral circulation to become established. The vast majority of our cases are done in two stages. We allow an interval of approximately three months to elapse between the first and second stages of the "push-back operation."

Experience has shown that a long interval of waiting between the first

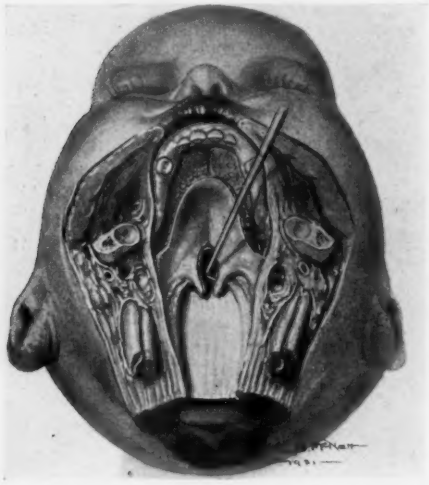


FIG. 15.—Shows the displaced palate completely free. Note how the ends of the relaxation incision are extended over the pterygomandibular fold. The borders of the cleft velum are also freshened.

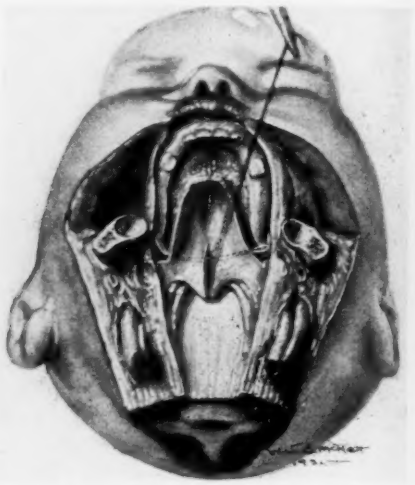


FIG. 17.—Shows the intramuscular wire suture in place and the silk coaptation sutures in the nasal mucous membrane.

and second stage is a wise procedure and rewards one with fewer partial or complete failures from sloughing. Not only is the collateral circulation better established but the tissues become thicker and will withstand much more trauma. In the first of these procedures, the relaxation incision is made, permitting the raising of the palatal mucoperiosteum from the underlying bone from before backward (Figs. 10 and 11).

The posterior palatine vessels and nerves are divided as the palatal mucoperiosteum is freed from its bed as far back as the attachment of the palatal aponeurosis; the flap is then replaced in its original position and held with sutures (Fig. 12). Seven days later, the sutures are removed. The second stage is performed after three months.

At times, especially in patients in whom the palatal tissue is thin, a lateral

incision is made on each side, leaving an anterior bridge of connection behind the incisors. This bridge is divided in the second stage of the operation (Fig. 13).

Three months after the primary operation, the collateral circulation being well established, as determined by the color and thickness of the flap, the final procedure is instituted. The mucoperiosteum is again raised and the palatal aponeurosis and nasal mucous membrane freed from their connection with the

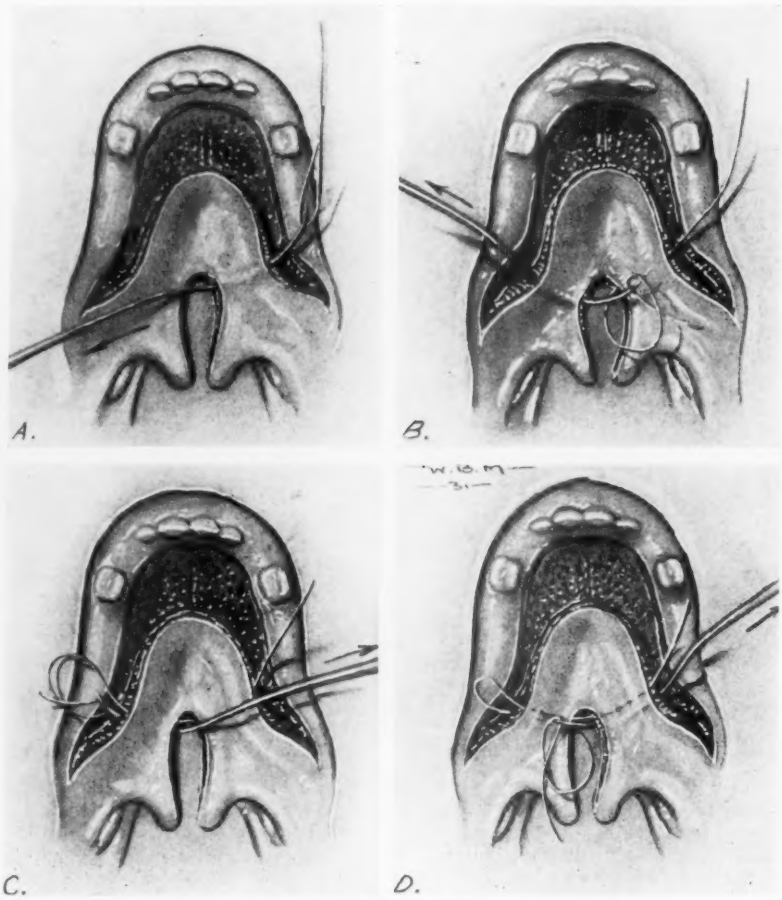


FIG. 16.—Depicts the placing of the aluminum-bronze suture through the muscle tissue. This suture was first used by Dr. Victor Veau, of Paris.

posterior border of the hard palate. The hamular process is divided on each side by means of a chisel applied above its connection with the mesial pterygoid plate. It is always necessary to extend the relaxation incision backward around the maxillary tuberosity and over the pterygomandibular fold to obtain sufficient mesial displacement of the muscular tissue (Fig. 14).

When tension is freed the two halves of the cleft palate meet easily in the mid-line, the velum will be in contact with the pharyngeal wall and when the

sutures are subsequently applied the "palatopharyngeal-sphincter" will be restored.

The next step (Fig. 15) is to denude the borders of the cleft and insert interrupted sutures in the nasal mucous membrane. The ends of these sutures are left long and are not tied until the insertion of the antitension intramuscular aluminum-bronze suture first suggested by Dr. Victor Veau of Paris. While a catgut suture may be substituted for this, we do not advise it. This suture is placed as shown in the diagram (Fig. 16).

The interrupted sutures passed on the nasal mucous membrane are now tied. The two ends of the wire suture, passed submucously around the muscle tissue, are twisted together so as to bring the flaps in intimate contact at the mid-line. The separated ends of the superior constrictor muscle are now in

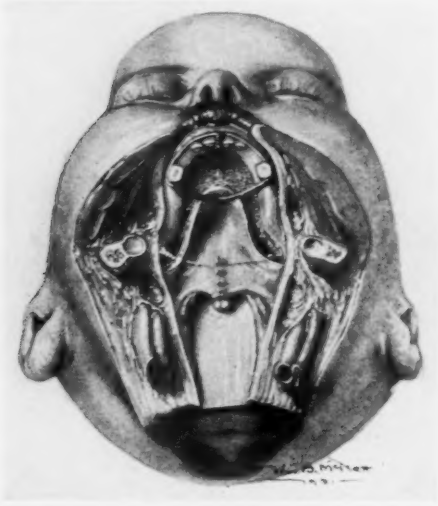


FIG. 18.—The cleft palate completely closed at the end of the "push-back operation." Note the wire support applied across the palate and around the maxillary teeth to hold the displaced palate upward against the bone.

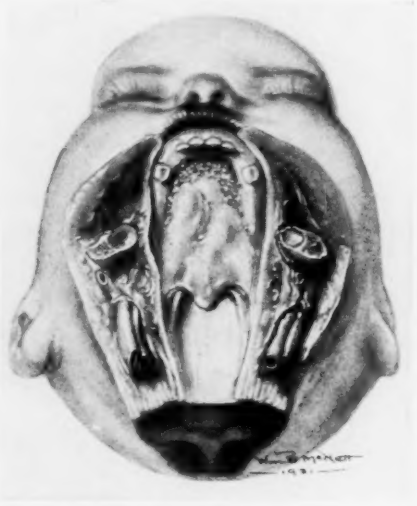
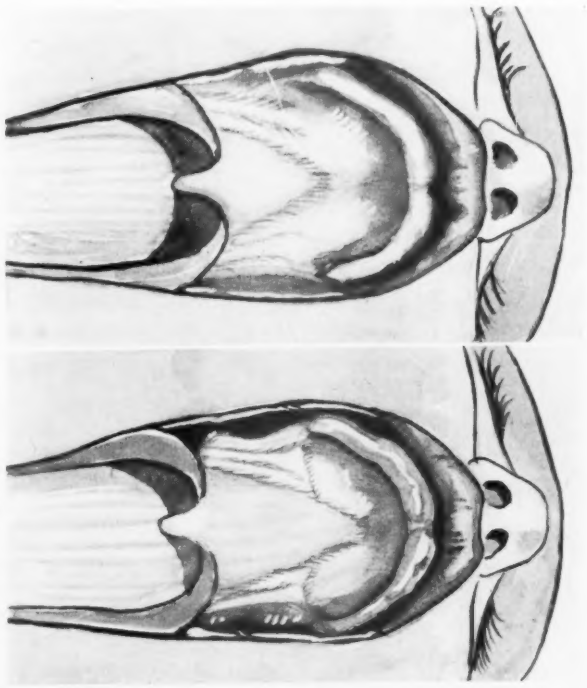


FIG. 19.—The healed palate after the "push-back operation." Note that the denuded bone has completely filled with granulation tissue. The cleft anterior segment of the pharyngeal ring has been restored, thereby restituting the split "palatopharyngeal-sphincter."

their proper relationship. No necrosis accompanies the use of this suture. We regard this aluminum-bronze suture the most important item in cleft-palate surgery (Fig. 17).

The oral mucous membrane is united with coaptation sutures. The anterior extremity of the displaced palate is held against the denuded palatal vault with a suture passed through the bone. A further support is obtained by passing a heavy piece of silver wire behind the premolar or between the molars, then across the palate and behind the same teeth of the opposite side, using wire of sufficient length so that the two ends can be molded around the dental arch meeting in front of the incisors where the ends are twisted together and turned back over the incisors (Fig. 18). Iodoform gauze is then placed between this wire splint and the united palate where it exerts



A B

FIG. 20.—A, Submucous split of the velum in which the split involves the muscle tissue alone, the palatal mucous membrane is intact. B, Submucous split palate in which the split runs through the hard and soft palate.

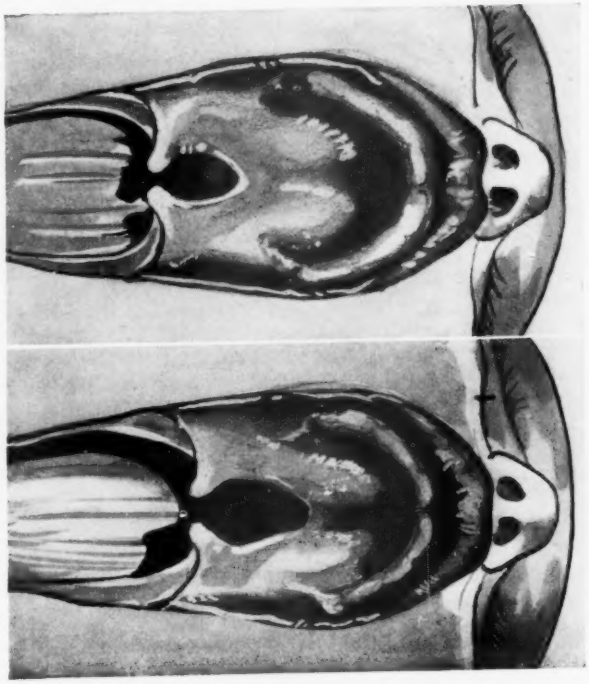
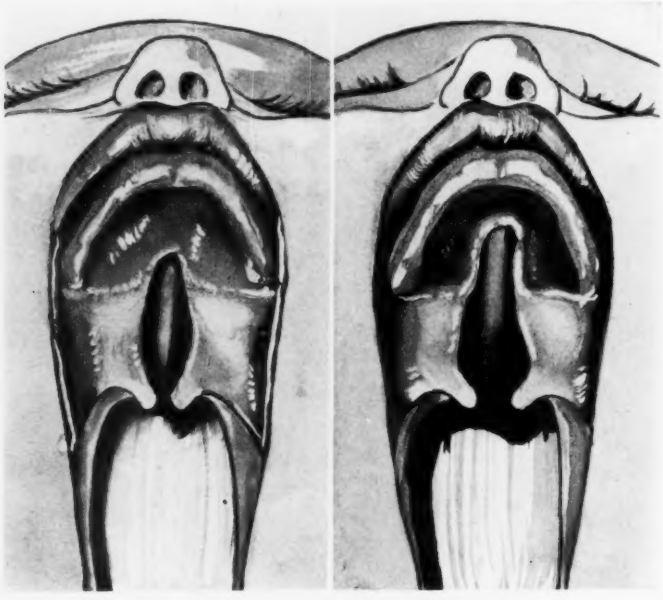


FIG. 21.—Splits of the velum.

slight pressure, prevents tongue contact, and supports the flap. This gauze is renewed after four days and is finally discarded when the palatal flap has adhered to the denuded bone. The denuded bone at the site of the relaxation incision becomes covered with granulation tissue (Fig. 19).

We feel that the "push-back operation" should be used in cases with congenital shortening of the palate (Fig. 20), cleft velum (Fig. 21), and cleft palate which extends as far forward as the junction of the anterior third with the middle third of the hard palate (Fig. 22). In these cases, the operation accomplishes complete restoration of the palate. We have found the "push-back operation" invaluable in reclaiming the palates of individuals on whom the usual cleft-palate operation has been done and the shortened palate fails to



A B

FIG. 22.—A, Split of the palate. The defect involves the hard palate in part. B, Split of the palate. The defect extends as far forward as the incisive fossa.

restore normal speech. When a defect in the anterior portion of the hard palate exists after the "push-back operation" we advise an obturator-plate to which is attached any missing teeth (Fig. 23).

In patients with lip-jaw-palate splits no primary operation for closing the breach in the alveolar ridge is necessary. Repair of the split lip will suffice because the normal pressure of the repaired lip will in time restore the continuity of the alveolar ridge.

In cases of complete lip-jaw-palate splits in which the soft tissue is of adequate length, a modified von Langenbeck procedure is performed after the cleft in the lip is closed and the breach in the alveolar ridge restored. In brief, this modification consists of division of the hamuli to release the lateral ten-

sion produced by the tensor palati muscles and extending the relaxation incisions over the pterygomandibular folds, the application of the submucous muscle suture of Victor Veau and the use of the two-stage procedure. If we find that satisfactory speech does not follow after sufficient time following operation on account of a shortened palate, we then do a "push-back operation."

It has been our experience that unless we obtain a successful closure of the palate and establish a fairly normal velopharyngeal closure, the speech will always betray the fact that the patient has had a cleft palate.

It has likewise been our experience to find a large percentage of adults even when these above conditions are attained will need speech training to get away from the faulty habits developed prior to operative interference.

We will not argue the old question of when is the best time to operate on cleft-palate cases but we will state our opinion that the "push-back operation" should not be attempted under the age of five years.

We seldom operate before that time and will often wait six months or longer in cases in which the operation might jeopardize the child's general health. As stated before, if the repair is performed in two stages, there will be less partial or complete failure.

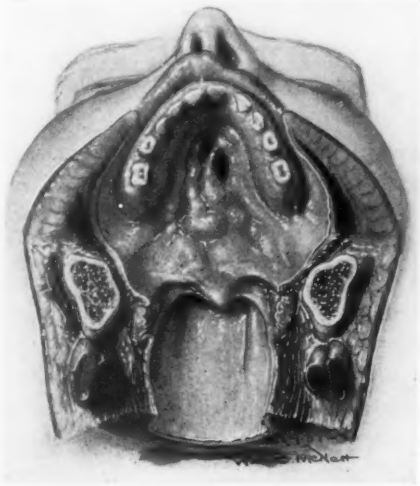


FIG. 23.—The same patient after the "push-back operation." Note the way the palate has been lengthened, thereby enabling the "palatopharyngeal-sphincter" to close the nasopharynx. The holes in the anterior portion of the hard palate will close after cauterization. If these holes persist they can easily be covered with a plate made of vulcanite.

In conclusion let us reiterate that the "push-back operation" is not advocated in every case of cleft palate. It is our belief, however, that it offers the best chance for obtaining good functional results in cases of short palate regardless of whether this shortening is congenital or the result of previous operative procedures.

Three factors to be emphasized:

1. The indication for the "push-back operation" in cleft-palate patients.

2. The age of choice at which the palate should be repaired is the fifth year of life.

3. The operation for cleft palate should be performed in two or more stages, depending upon the condition of the tissue.

MORTALITY IN SURGERY OF THE BILIARY TRACT

A COMPARISON OF TWO SIX-YEAR PERIODS

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and
William Erb, M.D.
of Philadelphia, Pa.

An effort is made in this paper to analyze factors which may have influenced the mortality rate in a series of consecutive operations on the biliary tract. All of these cases were operated upon on Service C at the Hospital of the University of Pennsylvania under one technic although by several operators so that individual differences in indications for operation, or type of operation attempted are eliminated as contributing factors to changes in mortality rate. All cases of operation upon the biliary tract are included in this compilation and all deaths are included in the mortality. It is, of course, self evident that a lower mortality rate should accompany a selection of cases with proven good liver function or where the disease is limited to the gall-bladder but if a patient requires biliary surgery it must be done whether he is a good or bad risk. This comparative series is an effort to show that increased pre-operative care, operative experience and lastly, but by no means least, the post-operative treatment, have caused a great reduction in mortality in the general run of cases. All deaths occurring within a 30 day period in the hospital are included as surgical deaths as well as all post-operative deaths occurring in the hospital at any time after the 30 day period if the cause of death was in any way connected with the surgical condition.

The type of pathology found at operation, the age of the patient, the duration of disease, type of incision and associated operations, the influence of opening the common duct and the importance of pre- and post-operative care will be discussed in detail.

The influence of the type of pathology found at operation on the mortality rate is summarized in the first chart. A total number of 537 cases was reviewed with 43 deaths with what at first appears to be an appalling mortality rate of 8.0%. However, a closer analysis reveals that by far the greater percentage of these deaths are due to associated conditions rather than to the surgery *per se*. For example, three cases of yellow atrophy are included who were stuporous when operated upon. One might state that it was an error in judgment to operate on this type of case. However, all these cases were operated upon after considerable thought and the fact that all were doomed without surgery justified an exploratory laparotomy with the almost forlorn hope of finding a silent stone obstructing the common duct. In all three cases the pre-operative diagnosis was probable yellow atrophy.

Eliminating these eight hopeless cases, the mortality rate for the entire

CHART I

Pathological Diagnosis	1922–34 No. of Cases	1922–34 Deaths	1922–34 Mort.	1922–28 No. of Cases	1922–28 Deaths	1922–28 Mort.	1928–34 No. of Cases	1928–34 Deaths	1928–34 Mort.
Chronic calculous cholecystitis Cholecystectomy	200	6	3.0%	76	4	5.3%	124	2	1.6%
Chronic calculous cholecystitis Cholecystostomy	56	2	3.6%	42	1	2.4%	14	1	7.1%
Chronic non-calculous cholecystitis Cholecystectomy	58	0	0 %	15	0	0 %	43	0	0 %
Chronic non-calculous cholecystitis Cholecystostomy	10	1	10.0%	3	0	0 %	7	1	14.3%
Acute cholecystitis Cholecystectomy	28	2	7.1%	10	1	10.0%	18	1	5.5%
Acute cholecystitis Cholecystostomy	51	3	5.9%	27	0	0 %	24	3	12.5%
Ruptured gall-bladder	9	1	11.1%	4	1	2.5%	5	0	0 %
Exploration of common duct	92	8	8.7%	37	7	18.9%	55	1	1.8%
Acute pancreatitis	12	7	58.3%	6	5	83.3%	6	2	33.3%
Ca. of biliary system	13	5	38.4%	5	2	40.0%	8	3	37.5%
Total	529	35	6.6%	225	21	9.3%	304	14	4.6%

Unclassified deaths: Cirrhosis 2
Yellow atrophy 3
Carcinoma of pancreas 3

Total number of cases—537 Deaths—43 Mortality—8.0%

series is 6.6% with the mortality during the last five years being only 50% of what it was the first five years, 4.6% as compared to 9.3%.

Of the remaining deaths 12 cases or 34.2% occurred in cases of carcinoma of the biliary system or frank cases of acute pancreatitis. These cases of acute pancreatitis all had fat necrosis on opening the abdomen and had to be drained. Cases of common duct stone obstructing by becoming lodged at the ampulla of Vater and then causing some œdema and hardness of the head of the pancreas are not included. These were included among the 92 cases whose common duct was explored.

Again attention is called especially to the remaining 23 deaths and the cause for the reduction in mortality rate as shown by the drop from 5.3% to 1.6% in chronic calculous cholecystitis and from 18.9% to 1.8% in cases requiring exploration of the common duct. A definite cause for death was found in only 5 of the 14 cases (1922–28) 3 of these dying as a result of pulmonary complications, 1 as a result of an infection and 1 as a result of post-operative hæmorrhage. Seven deaths occurred within 3 days of time of operation. The majority of these showed the syndrome of high fever, high pulse rate and low blood pressure and would probably be classified as liver deaths by the majority of authors. Two cases died from the syndrome which Whipple calls pancreatic asthenia. Both of these lost large amounts of bile from drainage tube. In contrast to this only 2 cases of death were unexplained by a definite pathological diagnosis in the 9 deaths since 1928. The causes of death in the others were as follows: pulmonary complications 1, ruptured wound 1, uræmia 1 and cardiovascular catastrophe 4. These last 4 cases were distributed as follows, first, cardiac failure on operating table; second, coronary thrombosis on 17th post-operative day; third, pulmonary embolism on the 11th post-operative day and fourth, sudden death in an individual who had a stroke 7 years before.

Before continuing with the discussion of the decrease in deaths which are commonly attributed to liver shock or pancreatic asthenia, one notices the marked increase in operations for chronic non-calculous cholecystitis. The number of non-calculous cholecystitis cases has increased 186% while the general increase in biliary surgery has been only 35%. This increase can probably be entirely attributed to the increased use of the Graham-Cole test of gall-bladder function. There are no deaths in this group of 56 cases. This at first thought would appear to be very encouraging, assuming that the Graham-Cole test made diagnosis possible in an earlier stage of disease. However, in Chart II one finds that the average duration of disease as obtained from the patient is almost identical in chronic non-calculous and chronic calculous cholecystitis. The conclusion which is then arrived at as the most logical is that removal of the gall-bladder itself is a procedure of slight danger, but that the cause of death is usually the associated pathology or in a few cases—some unforeseen catastrophe.

The operation of choice in gall-bladder disease was cholecystectomy, unless the patient was too ill or the difficulty of the operation was thought too hazard-

CHART II

	1922–28				1928–34			
	Average Age	Sex		Duration of Symptoms	Average Age	Sex		Duration of Symptoms
		Male	Female			Male	Female	
Chronic calculous cholecystitis								
Cholecystectomy	41.5 yrs.	12.8%	87.2%	4.2 yrs.	43.5 yrs.	22.4%	77.6%	5.3 yrs.
Chronic calculous cholecystitis								
Cholecystostomy	48.5	19.5	80.5	4.2	50.2	18.2	81.8	4.1
Chronic non-calculous cholecystitis								
Cholecystectomy	41.7	11.1	88.9	5.3	37.8	17.5	82.5	5.2
Acute cholecystitis								
Cholecystectomy	39.8	50.0	50.0	4.1	38.6	6.7	93.3	5.3
Acute cholecystitis	53.0	17.4	82.6	9.1	43.5	25.0	75.0	7.2
Common duct investigated	49.0	24.0	76.0	6.8	50.5	32.0	68.0	4.0
Deaths	47.0	34.6	65.4	4.2	56.0	35.0	65.0	4.0

CHART III

Age		10–30		30–40		40–50		50–60		60–70		70–80	
		No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.	No.	Per Cent.
Chronic calculous	22–28	7	10.3	28	41.2	17	25.0	11	16.2	4	5.9	1	1.4
Chronic cholecystectomy	28–34	8*	7.7	34	32.8	32	30.7	25	24.0	4	3.8	1	1.0
Chronic calculous	22–28	3*	6.5	7	15.2	12	26.1	15	32.6	8	17.4	1	2.2
Cholecystitis Cholecystectomy	28–34			2	18.2	3	27.2	4	36.4			2	18.2
Chronic cholecystitis	22–28	3	16.7	4	22.2	6	33.4	4	22.2	1	5.5		
Cholecystectomy	28–34	7	15.9	13	29.6	21	47.7	3	6.8				
Acute cholecystitis	22–28	2	20.0	4	40.0	3	30.0	1	10.0				
Cholecystectomy	28–34	1	6.3	10	62.4	1	6.3	2	12.5	2	12.5		
Acute cholecystitis	22–28	1	5.0	5	25.0	5	25.0	3	15.5	5	25 0	1	5.0
Cholecystostomy	28–34	1	4.2	6	25.0	9	47.4	4	16.0	4	16.7		
Common duct	22–28	1	3.6	4	14.3	13	46.4	2	10.7	6	21.4	1	3.6
Investigated	28–34	1	1.8	8	14.5	15	27.3	18	32.8	11	20.0	2	3.6
Deaths	22–28	1	3.8	5	19.2	8	30.8	9	34.6	3	11.6		
	28–34	1	5.9	2	11.7	2	11.7	3	17.7	6	35.3	3	1.7
Total		37	7.6	132	27.2	147	30.3	105	21.6	52	10.7	12	2.5

* One case below 20.

ous by reason of excessive obesity, difficult anæsthesia or difficult exposure because of induration or œdema of an insurmountable nature around the ducts. All acute cholecystitis patients were operated upon if 24 hours of palliative treatment did not result in relief. If relief occurred surgery was postponed for 10 days. In jaundiced patients, free of pain, palliative treatment was conducted for 72 hours and if no decrease in jaundice occurred, they were subjected to surgery after glucose, blood and fluid preparation. Calcium has not been used in any of the last 6 year group.

The age of the patient is naturally a very important factor in the question of operative risk. This is emphasized, if that is necessary, by the fact (Chart III) that 70% of deaths from 1928 to 1934 occurred in patients over 50 years of age. Realizing this it was thought that possibly operations in general were done on a younger group of patients from 1928 to 1934 than from 1922 to 1928, because of various improvements in diagnosis. However, Charts II and III show that in the greater proportion of cases a slightly older group was being operated upon. This bears out the well known axiom that the age of a surgical practice increases with the age of the surgeon and the age of his referring physicians.

The duration of disease before intervention was practically identical in the two periods. However, importance of early diagnosis and early operative intervention is shown by the fact that cases requiring investigation of the common duct gave a history of biliary disease of longer duration than those cases of chronic calculous cholecystitis in which simply a cholecystectomy was done. The actual age was also approximately seven years above that of those cases not requiring investigation of the common duct. Another fact that one might point out in passing is that though average age of biliary disease patient is somewhere in the fourth decade only 30.3% of the cases' age is actually between 40 and 50. Contrary to the usual text-book description of "fair, fat and forty"—almost the same number of patients are in the age group between 30 and 40 as between 40 and 50.

Since 1930 the subcostal incision has been always the incision of choice. Better exposure of biliary tract is obtained and thus danger of biliary surgery is decreased. The follow-up records show that percentage of wound defect compares very favorably with transverse incision or paramedian incision but that percentage of post-operative hernias is somewhat lower when the right rectus is employed. The lower mortality rate in cases in which the subcostal incision was used we believe may be partially due to better exposure but largely due to coincident factors. The subcostal incision has been criticized because it does not as readily permit a routine appendectomy. This contention cannot be denied. The number of routine appendectomies has been decreased by 50%. However, it is a debatable point whether this is an advantage or disadvantage of the incision as it is the writers' belief that appendectomies should only be done when there is a clear indication for same.

Every case of cholecystectomy was drained, although this procedure may possibly give greater morbidity according to some writers. In this series at

least the lives of two patients who drained bile profusely for 4 to 7 days post-operatively were saved by reason of a routine cigarette drain. It was impossible to tell at the time whether the drainage was the result of an accessory duct, raw liver surface or a slipped ligature. There were no deaths as a result of so-called bile peritonitis.

The most marked improvement in mortality rate has been in those in which the common duct was explored; a drop from 18.9% to 1.8%. Therefore, this group was studied in slightly greater detail. Someone might say that following the teachings of Clute of Laheys' Clinic a greater percentage of common ducts were opened and thus the lower mortality rate. This is only partially true, as the per cent. of common ducts investigated was only very slightly higher than in the first six years. The figures do tend to support Clute's contention that if a greater percentage of common ducts were opened a larger per cent. of common duct stones would be found.

CHART IV

	Incisions	Wound Defect Per Cent.	Mortality Per Cent.
Type subcostal	285	4.2	5.2
Right rectus	100	2.0	15.0
Transverse with or without flap	91	6.6	9.9
Paramedian	41	9.7	7.3

1. Three ruptured wounds—1 resulting in death
2. Two ruptured wounds—no death

Associated Operations

	1922–28		1928–34	
	No.	Per Cent.	No.	Per Cent.
Appendectomies	41	18.2	27	8.9
Posterior gastrojejunostomy	6	2.7	6	1.9
Herniorrhaphy	0	0	2	.6

The case in which the common duct is investigated is the one most likely to require expert pre- and post-operative care. More of these cases are jaundiced and as a result of this have a greater or less degree of liver damage. Graham, Ravdin and others have repeatedly emphasized the value of intravenous glucose in the preparation of these cases and in their post-operative care. The importance of this is beyond doubt. The intermittent method of administration is preferred to the continuous intravenous drip as one of the patients developed a severe phlebitis from the latter method. A small transfusion pre- and post-operatively certainly enhances the patient's chance for recovery. These two facts are so well established that one need say nothing further of their importance. However, emphasis should be placed on the importance of feeding bile by Jutte tube in certain common-duct drainage cases in which a large amount of bile is lost daily. Little or no reference to this is found in the surgical literature of the past eight years. Since the institution of this practice we have had no death from liver shock or so-called

pancreatic asthenia, the one death in the past fifty-five cases occurring in an individual 79 years of age who was stuporous at the time of operation and died the same day.

The technic is briefly as follows: On those cases in which the common-duct drainage has been large (700 or more cubic centimetres daily) for four or five days, the bile is collected and given to patient through a Jutte tube put into patient's stomach through the nose. This Jutte tube is allowed to remain in place and bile is poured into a regular intravenous cannula and given intermittently. The improvement in appetite, volume of pulse and general condition of patient is sometimes striking. This has been considered so important that if there has been a leakage of bile on dressings an effort has been made to wring bile out of dressings and give it to patient.

CHART V

Common Duct Investigated

Operation	1922–34	1922–28	1928–34
Choledochostomy	18	9	9
Choledochostomy and cholecystectomy	27	9	18
Choledochostomy and cholecystostomy	47	19	28
Total number	92	37	55
Stones found	54	21	33
Per cent.	58.5	56.7	60.0
Per cent. of ducts opened to total number of operations	17.4	16.4	18.1
Per cent. of stones found to total number of operations	10.2	9.3	10.8

The value of the above three factors can probably be best illustrated by the following brief abstract of a typical case.

Patient, white, male; aged 69; history suggestive of both ulcer and gall-bladder disease. Physical examination—emaciated elderly man with definite icterus. Blood-pressure 126/70, pulse 62, temperature 98°, respirations 26, vessels sclerotic, heart enlarged with numerous extra systoles. Laboratory data: Hæmoglobin, 75 per cent.; white blood-cells, 12,600. Urine negative. Gastro-intestinal X-ray, duodenal ulcer, duodenal drainage negative. Pre-operative preparation—500 cubic centimetres citrated blood three days prior to operation and 1,000 cubic centimetres 5 per cent. glucose daily for three days. Operative diagnosis—duodenal ulcer, cholecystitis and choledochitis. Operative procedure—posterior gastrojejunostomy, choledochostomy, cholecystostomy. Hard mass in region of ampulla—but no further surgery attempted because of condition of patient. Post-operative two 250-cubic centimetre citrated blood transfusions and daily intravenous of 1,000 cubic centimetres 5 per cent. glucose. Drained about 1,000 cubic centimetres bile daily, temperature 100°, pulse 70, respirations 28. Convalescence surprisingly uneventful. Fifty per cent. of biliary drainage given by mouth after fifth day. In spite of this on twelfth post-operative day he had a sudden collapse. Blood-pressure 80/60, temperature 96°, pulse 92, leaky skin. He was given 1,000 cubic centimetres 5 per cent. glucose intravenously, 500 cubic centimetres citrated blood and all of biliary drainage. He improved immediately and continued to do so with aid of biliary feedings and another

transfusion of 500 cubic centimetres blood. Biliary drainage continued but diminished and he was discharged to the care of his family physician on his thirty-fifth post-operative day. However, he became worse and was readmitted at end of ninth day. Again suffered from weakness and loss of appetite. Prepared in a similar manner as for first operation, though preparation required ten days. At operation unable to determine definitely cause for obstruction and a cholecystduodenostomy done. His post-operative convalescence quite uneventful and he was discharged on his twenty-fifth post-operative day.

SUMMARY

Two six-year groups have been compared from which the following conclusions have been drawn:

(1) The improvement in pre- and post-operative care appears to be the most important single factor in lowering our mortality rate in biliary surgery during the past twelve years.

(2) Too much emphasis cannot be placed on the value of intravenous glucose, transfusion, and the feeding of bile by Jutte tube in the common-duct drainage cases.

(3) The Graham-Cole functional test has caused a marked increase in cholecystectomies in non-calculous cholecystitis. However, in this series of cases the average age of the patient and the duration of the disease have not been decreased in the past six years.

(4) The subcostal incision has almost entirely replaced the right rectus or transverse incision in the latter years.

(5) There has been an increasing tendency to do fewer and fewer incidental appendectomies.

(6) We have been slightly more prone to investigate the common duct in the past five years with a slight increase in the per cent. of common-duct stones found.

(7) As a result, therefore, the mortality for the last five years has been reduced 50%.

PILONIDAL CYSTS

TREATMENT BY EXCISION AND PRIMARY SUTURE IN AMBULATORY PATIENTS

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The controversy over the pathogenesis of pilonidal cysts is paralleled by the lack of uniform opinion as to the best method of their treatment. This paper proposes to briefly outline some of the characteristics of these cysts and to compare the results which may be obtained by incision and drainage, or excision and packing, with those observed following excision with primary suture in ambulatory patients.

The pathogenesis of pilonidal cysts is not settled. There are two chief theories which have many adherents. Lockhart-Mummary,[1] Stone,[2] Hertzler,[3] and many others regard this lesion as a sequestration dermoid, an epithelial down growth. Weeder[4] has recently upheld the belief of a large group of authors who attribute the cyst formation to a lack of complete obliteration of the lower neurenteric canal. It appears certain that the lesion is congenital in origin. It seems to be entirely confined to the white race, at least no cases have been reported in Negroes. The incidence of pilonidal cyst is much greater in men than in women; in this series, males thirty-seven, females five. They tend to occur more often in fat, hairy individuals.

As a rule, the presence of the cyst escapes the patient's notice until early adult life (Table I), although patients frequently may observe a thin serous discharge from the cyst opening, or they may extract protruding hairs from its orifice. Usually, however, they are brought to the patient's notice by the pain of an inflammatory swelling in and around the cyst.

Table I

Incidence of Pilonidal Cysts According to Age at the Time of Treatment

Age in Years	9	10–15	16–20	21–25	26–30	31–35	40 and up
No. of Cases..	1	1	12	18	5	2	4 (the oldest patient was 48)

On examination, a characteristic lesion is found, varying somewhat according to the duration of the symptoms. In early cases a tender swelling is present over the lower sacrum, and in the mid-line, between the folds of the buttocks and about two inches posterior to the anus, may be seen one or several round or oval openings. As a rule, there is one larger opening and one or several smaller ones on the anal side of the main orifice. Pus or hair may be found to escape from the cyst orifice. If hair protrudes, the diagnosis

is certain. If pus escapes the diagnosis may be confused with that of anal fistula, but the pilonidal cyst can usually be identified easily by the fact that the orifice is smooth, lined with skin and always situated in the mid-line in back of the anus, whereas the external orifice of an anal fistula is rarely in the mid-line and is always marked by a heaped-up ring of recent or old granulation tissue. If necessary to confirm the diagnosis, a probe may be inserted into the opening. It will pass upward over the posterior surface of

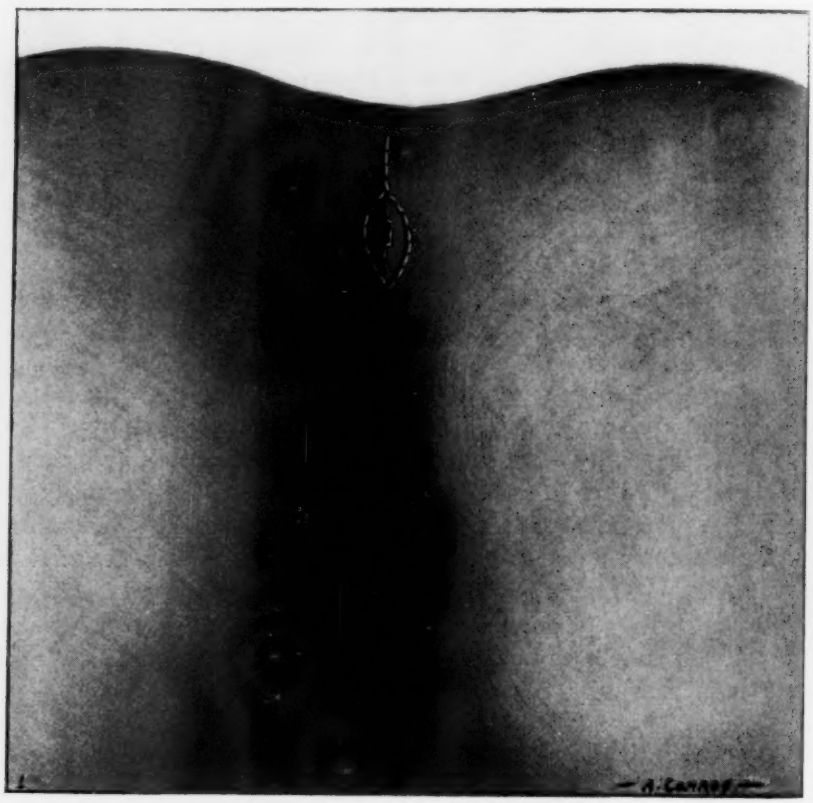

FIG. 1.—The patient is placed on the abdomen with a pillow under the pelvis or the operation may be performed on the proctoscopic table partially tilted. A superficial and deep infiltration anæsthesia with 1 per cent. novocaine-adrenalin is used. The incision should be in the mid-line except where it surrounds the openings of the cyst.

the sacrum in pilonidal cyst, but passes into or toward the anal canal or rectum in fistula-in-ano.

In late cases the findings may be somewhat altered by the *sequelæ* of recurrent inflammations. Secondary chronic sinus openings often are found on one or the other side of the mid-line but almost invariably away from the anus over the lower part of the body of the sacrum. The induration leading from these secondary sinuses may often be palpated as a definite inflammatory bar extending down and back toward the skin opening or dimple in the mid-line.

In acute inflammations the cyst and the surrounding area is marked by an intense swelling and redness. The cyst is often plugged so that no pus escapes but the dimple is always present in the mid-line. The position of the swelling over the lower sacrum distinguishes the infected pilonidal cyst from the more common ischiorectal abscess, which is usually found lateral to the anus, near to the anal opening. Tenderness and induration on digital examination of the anal canal are constant findings with ischiorectal abscesses which are not present in infected pilonidal cysts.

The injection of radiopaque solutions and an X-ray picture has been suggested as a means of diagnosing and identifying the extent of the pilonidal

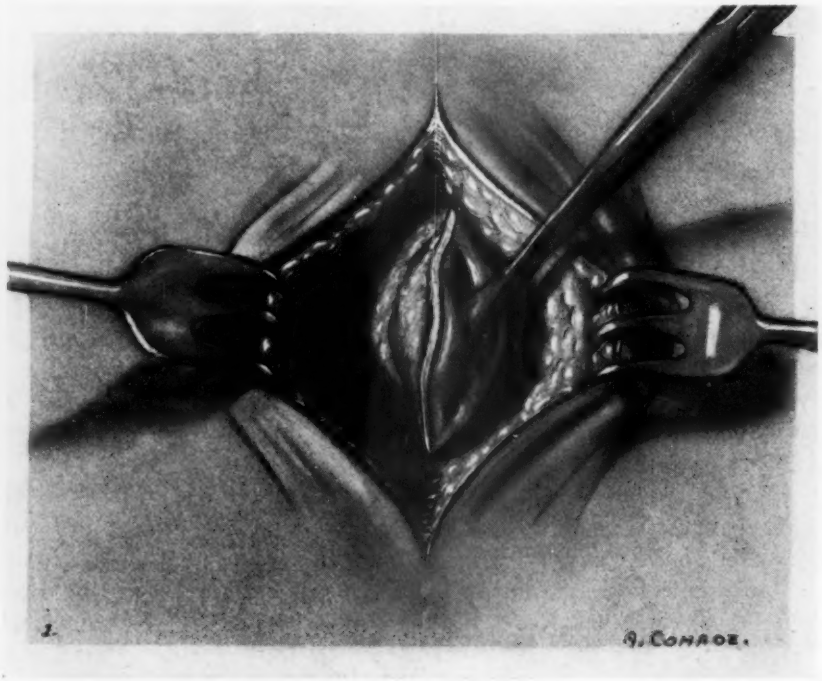

FIG. 2.—The sinus-like lower part of the cyst is dissected free, the tissues being kept on tension between the lateral rake retractors and the cyst opening held in an Allis forcep.

cyst. This is a refinement of diagnosis that is rarely necessary, and is certainly neither helpful nor advisable in the care of the usual infected cyst.

In the cases coming under observation many methods of treatment have been used and a comparison of the results obtained furnishes a good evaluation of their merit.

Incision and drainage of the infected pilonidal cyst was employed in sixteen cases. In many of these cases the lesion was diagnosed as an abscess by the family physician and the incision was made before the patient was referred to the hospital. In all of the cases which could be followed (fourteen), recurrence followed. We have not as yet employed Carnoy's solution after incision and drainage as suggested by Cutler and Zollinger,[5] but in two cases the

cyst-wall was cauterized with pure phenol at the time of operation and the recurrences have been slight and responded well to treatment by injections with Carnoy's solution (see below).

Excision of the infected cyst and packing of the wound was the treatment employed in ten cases. None of these operations was performed by the writer but all of them were referred either to the surgical out-patient department or the Student Health Service for dressings. All of these patients with two exceptions were hospitalized from six to twelve days, averaging about eight days. The patient was then permitted to become ambulatory. The wound was loosely packed with plain gauze and permitted to heal by granulation. Dressings were required every other day and at times every day when the edges of the wound became excoriated by the irritating wound secretion.

The results of this method of treatment were not too good. The healing period was long, the shortest being four weeks and the longest ten months. Of the nine cases followed the healing periods were as follows:

Time	4 wks.	10 wks.	12 wks.	20 wks.	30 wks.	32 wks.	40 wks.
Cases	1	2	1	1	2	1	1

It may be seen, therefore, that the healing period following excision of pilonidal cyst and packing is not a matter of three or four weeks, as often stated in text-books, but is more often one of three or four months. Further, recurrence was not infrequently observed after this method of treatment. Of the nine cases followed there was a recurrence in five cases. The long period of treatment necessary after excision and packing, the frequency of recurrence, and the unnecessarily long period of hospitalization for a simple superficial cyst infection made it seem worth while to adopt some other form of therapy. In order to avoid if possible the prolonged period of post-operative dressings, an excision of the cyst with primary suture of the wound was performed. The hospitalization was avoided by treating these patients as ambulatory cases, all of the operations being performed under local anæsthesia.

Twenty-four patients have been treated by this method of therapy and the results have been so much improved over those previously observed that a description of the care and operative technic seems worthy of mention.

Rule I.—No attempt at radical excision should be made while the cyst is acutely inflamed. This rule was followed (1) because the dissection of the cyst is more difficult when it is the seat of an acute inflammation; (2) because the use of a local anæsthetic is less effective if not actually contra-indicated in the presence of an acute inflammation; (3) because the chance of primary union of the wound without infection is greater if the operation is performed when the cyst shows no infection or only a chronic draining sinus.

In order to carry out this plan, radical excision was delayed in many cases. In fourteen of the twenty-four there was a history of previous spontaneous drainage through the cyst opening, or the opening could be dilated with a hæmostat and a small rubber dam drain inserted. Hot wet dressings were prescribed and two or three weeks later the operation was performed when the acute inflammatory symptoms had disappeared. In the remaining cases adequate drainage could not be obtained through the cyst open-

ing. In such cases simple incision of the cyst through a line infiltration with ½ per cent. novocaine and drainage with rubber dam or iodoform gauze was practiced. After application of hot moist dressings for two or three days the acute symptoms subsided and excision of the cyst could be performed in three or four weeks.

RULE II.—In effecting a primary closure after excision of a pilonidal cyst, especially in an ambulatory patient, it is essential to preserve as much normal tissue as possible. Therefore, the incision should be made so as to excise only the skin immediately surrounding the sinus opening and any other secondary sinus openings which may have developed spontaneously following an infection. The dissection should closely follow the outline of the cyst, to avoid unnecessary removal of any fatty tissue needed to fill the cavity left after removal of the cyst.

RULE III.—Local infiltration and field block anæsthesia is used in all patients. The

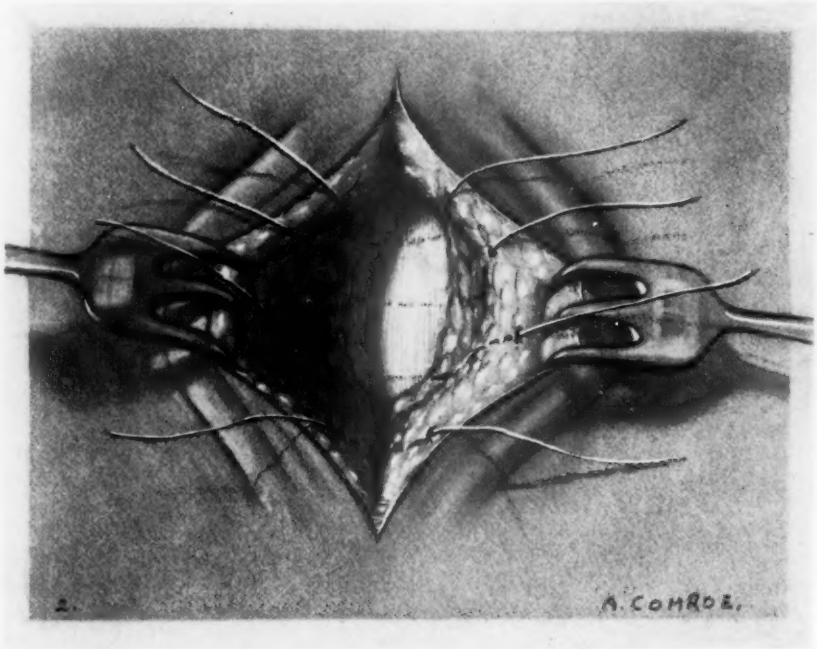

FIG. 3.—The cyst has been excised, exposing the dense tissue on the posterior surface of the sacrum. The depths of the wound are closed with buried interrupted sutures of fine catgut. These should effectively obliterate dead space by catching the sides of the wound and the dense tissue over the sacrum. All the sutures should be inserted before any are tied.

anæsthetic solution, 1 per cent. novocaine, should contain eight to ten drops of 1-1000 adrenalin hydrochloride solution. The use of a local anæsthesia makes the post-operative ambulatory care of these patients a simple matter. The adrenalin is a very important addition since by its use a practically bloodless field is obtained. This makes the operation more rapid, and permits a more careful dissection. With the addition of adrenalin to the novocaine solution, it is rarely necessary to ligate a single vessel.

RULE IV.—The entire cyst must be removed to prevent recurrence. The dissection of a pilonidal cyst is somewhat more difficult than that of an ordinary sebaceous or other retention cyst because there is no definite capsule which can be followed. In some cases following recurrent infections there may be a wall of induration which can be easily identified, but in cysts which have been infected only once or twice this demarcating wall is not present. In such cases the epithelial lining may be identified by injecting the cyst

with methylene blue through its opening or through a secondary sinus. As a rule the injection can best be made with the ordinary tip of a Luer or Record syringe and only about one cubic centimetre of solution should be used. As soon as the tip of the syringe is removed from the sinus opening, a gauze sponge should be placed over the opening and the cyst gently massaged to spread the colored solution over the entire cyst cavity and to milk out any excess of solution through the sinus tract. If an excess of methylene blue remains in the cyst cavity and the cyst be opened accidentally during the dissection, the colored fluid leaks out into the wound cavity and confuses rather than aids the dissection.

Although the opening of a pilonidal cyst is always found in the mid-line, the body of the cyst often extends upward on one or the other side of the mid-line. Sometimes the direction of the cyst extension may be known before operation by the presence of a secondary sinus opening or the position of the cyst swelling. Often, however, it may be impossible to completely outline the cyst before operation. In such cases the incision should be made around the cyst opening and upward toward the sacrum in the mid-line. With opposing rake retractors placing the lips of the wound on tension, the lowermost sinus part of the cyst may entirely be freed by incision. When once a starting line of cleavage is obtained between the periosteum over the sacrum and coccyx and the cyst, the dissection is made easier by grasping the cyst opening with Allis forceps. As alternate lateral and upward tension is obtained between the cyst and the lateral retractors, the cyst may be easily and completely dissected away from the surrounding areolar tissue.

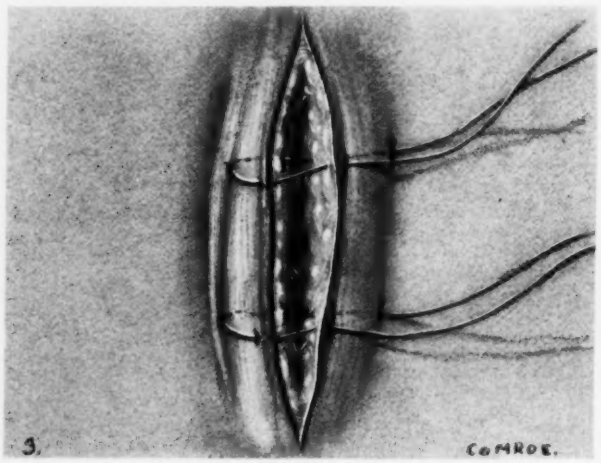

FIG. 4.—Dead space is further obliterated by closure of the skin, using vertical mattress sutures of silk.

RULE V.—To effect a primary closure after excision of a pilonidal cyst, especially in ambulatory patients, it is necessary to completely obliterate all dead space in the wound cavity. This end is accomplished by careful closure of the opening and by the application of post-operative pressure over the wound area. Closure of the wound is by a layer of buried fine interrupted catgut sutures so placed as to catch the entire inner surface of the wound. In placing this stitch it is especially important that the fat forming the lateral walls of the wound cavity should be caught as well as the periosteum covering the posterior surface of the sacrum. All of these sutures should be inserted before any are tied. The skin is usually well approximated when these stitches are tied, but tension on the wound edges can be further relieved and dead space further obliterated by the insertion of several silk vertical mattress sutures in the skin. Over the wound a pressure dressing is then applied. The dressing should be narrow over the wound and should gradually become wider, three or four folded gauze compresses being used. Pressure is maintained and tension is relieved by the application of tight adhesive strips transversely across the buttocks. The adhesive strips should extend far to each side and should be applied with the buttocks held together by an assistant. Pressure is further maintained by having the patient lie on his back for a period of at least one

hour after operation. By these measures dead space is obliterated in the wound cavity and a collection of blood and serum is prevented. This is the best prophylaxis against post-operative wound complications.

RULE VI.—Early removal of skin sutures is advisable if infection of the wound is to be avoided. Post-operatively there is always a slight moisture about the wound and stitch infections are prone to develop. If the sutures are removed on the third or fourth day after operation this complication can usually be avoided.

From Table II may be seen the results obtained in the treatment of pilonidal cysts by excision and primary suture, following the rules laid down above. All but three of the patients were ambulatory throughout their treatment. Seven of these were students, none of whom missed classes on account of their operation. The last post-operative dressing was fourteen days or less from the date of operation in about one-half of the cases. All the wounds except two were healed within three weeks after operation. The wounds which healed the poorest were those in which drainage had been inserted or in which operation was performed while the cyst was the seat of an acute inflam-

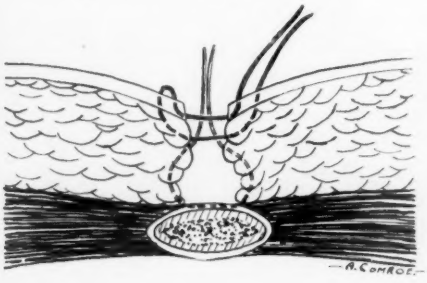

FIG. 5.—Cross-sectional view of wound showing suture position.

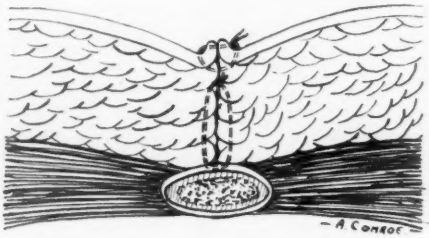

FIG. 6.—Cross-sectional view of wound closure after sutures have been tied. Note absence of dead space.

matory process. There was one recurrence in the group three months after operation. There are twelve cases operated upon more than one year ago (three, three years; five, two years, and four, one year); in none of these has there been a recurrence. The wound had to be reopened in only one case because of infection.

The method of treatment as outlined above has few disadvantages. Ambulatory treatment of these lesions is perfectly feasible; most patients prefer it. Usually three to four doses of acetylsalicylic acid gr. v-x is prescribed for the first twenty-four hours after operation. Often patients are surprised at how little pain is experienced. The adhesive strapping often gives more discomfort than the operative wound. The first dressing is performed on the third day after operation. At this time the skin sutures are usually removed and if there is any sign of an inflammatory reaction about the wound or suture openings a folded gauze compress moistened in 70 per cent. alcohol is applied. It is important to hold the buttocks together tightly with adhesive over the dressing for a period of about seven days, otherwise a spreading of the wound may occur when the patient sits down.

Recurrence of pilonidal cyst infection following simple incision and drain-

TABLE II

Case No.	Age	Sex	Previous Symptoms or Treatment	Condition of Cyst at Operation	Oper. Var. Other Than Excision and Suture	Period of Post-operative Treatment	Hosp. Days	Ambulatory Treatment	Recurrence	Remarks
1	20	M.	recurrent drainage	quiescent	none	9 days	none	yes	none—2 yrs.	Medical student, missed no classes
2	19	M.	recurrent drainage	quiescent	none	8 days	none	yes	none—4 mos.	Student, missed no classes
3	20	M.	incision and drainage	quiescent	rubber dam drainage	21 days	none	yes	none—2 yrs.	Student, missed no classes
4	17	M.	none	acute inflammation	none	60 days	none	yes	none—8 mos.	Wound opened during 400-mile auto ride—7 days
5	21	M.	recurrent drainage	quiescent	none	7 days	none	yes	none—6 mos.	Student, missed no classes
6	23	M.	recurrent drainage	quiescent	none	7 days	none	yes	none—6 mos.	Student, missed no classes
7	17	M.	incision and drainage	quiescent	rubber dam drainage	13 days	none	yes	none—2 yrs.	Student, missed no classes
8	40	M.	incision and drainage	quiescent	none	10 days	none	yes	yes—3 mos.	
9	41	M.	previous operation	quiescent	none	21 days	none	yes	none—2 yrs.	
10	22	M.	recurrent drainage	quiescent	none	18 days	none	yes	none—3 yrs.	
11	25	F.	recurrent drainage	moderate inflammation	none	15 days	none	yes	none—3 yrs.	
12	23	M.	previous operation	quiescent	none	12 days	none	yes	none—1 yr.	
13	19	M.	recurrent drainage	quiescent	none	10 days	none	yes	none—6 mos.	
14	18	F.	incision and drainage	quiescent	none	16 days	none	yes	too recent	
15	44	M.	incision and drainage	quiescent	none	17 days	none	yes	too recent	
16	22	M.	incision and drainage	quiescent	none	8 days	6 days	...	none—6 mos.	
17	35	M.	recurrent drainage	quiescent	none	20 days	none	yes	none—1 yr.	
18	17	M.	recurrent drainage	quiescent	none	8 days	none	yes	too recent	
19	25	M.	recurrent drainage	quiescent	none	10 days	none	yes	none—1 yr.	
20	30	F.	drainage with each mense	quiescent	none	8 days	none	yes	none—2 yrs.	
21	25	M.	recurrent drainage	quiescent	none	11 days	4 days	...	too recent	
22	23	M.	previous operation	quiescent	none	15 days	none	yes	none—3 yrs.	Student, missed no classes
23*	20	M.	recurrent drainage	quiescent	none	4 wks.	none	yes	none—6 mos.	Wound was re-opened
24*	28	M.	recurrent drainage	moderate inflammation	none	20 days	9 days	...		

* Observed, but not personal cases.

age or following incomplete operations performed elsewhere has been observed in ten cases. In three of these excision with primary suture was performed. Following the appearance of the article by Cutler and Zollinger[5] on the use of Carnoy's solution, the solution was injected into the recurrent sinus tract in four cases. Good results were obtained in three cases. The method warrants further trial.

SUMMARY

Pilonidal cyst presents such a definite clinical picture that its diagnosis is usually not difficult.

Treatment by simple incision is practically always followed by recurrence. Incision followed by the use of Carnoy's solution may be a preferable method of therapy.

Excision of the cyst and packing of the wound is followed by a prolonged period of dressings. Recurrences were frequent in the cases observed.

The treatment giving the best results seemed to be excision when the cyst was not infected followed by primary suture of the wound. The operation is best performed under local block anæsthesia with 1 per cent. novocaine-adrenalin solution. Care in obliterating dead space in the wound by accurate suture and post-operative pressure favors primary wound union. The patients may be ambulatory throughout the entire period of their treatment. Of twenty-one cases so treated all but two were discharged from the care of a physician with healed wounds by the twenty-first post-operative day. There was one recurrence three months after operation. Twelve cases have shown no recurrence in one to three years.

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CARDIAC IMPROVEMENT FOLLOWING GALL-BLADDER SURGERY

ELECTROCARDIOGRAPHIC EVIDENCE IN CASES WITH ASSOCIATED MYOCARDIAL DISEASE

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The difficulties of differential diagnosis between certain forms of heart-disease attended by pain and certain types of gall-bladder disease have long been emphasized. An attack of angina pectoris or acute coronary occlusion may so closely mimic acute calculous obstruction of the biliary tract, or some other more surgically imperative catastrophe in this region that the surgeon may be disastrously tricked into operating. Conversely a patient with gall-stone disease may present such a convincing array of cardiac symptoms that the internist may wrongly condemn the sufferer to a "life sentence" of cardiac servitude.

In addition to this problem of mimicry, which is not the immediate concern of this report, there is a growing conviction among internists and surgeons alike that chronic disease of the gall-bladder may either initiate or aggravate actual heart-disease—especially so-called coronary heart-disease.[1] This belief is based largely on observed cardiac improvement following gall-bladder surgery in certain individuals with myocardial disease whose associated gall-bladder trouble became so distressing that surgical intervention was deemed imperative, despite apparent cardiac contra-indications to operation.

The successful removal of gall-stones, preferably by cholecystectomy but sometimes of necessity by cholecystotomy or choledochotomy, has been followed by (a) restoration of cardiac compensation in a few cases of chronic congestive heart-failure; (b) restoration of normal rhythm in certain cases of chronic or paroxysmal auricular fibrillation and paroxysmal tachycardia, and (c) marked amelioration and sometimes apparent cure of a more or less incapacitating syndrome of angina pectoris or of what at first seemed to be a major attack of coronary occlusion.

This last group of patients, apparently afflicted with angina pectoris or coronary occlusion and subsequently relieved by cholecystectomy, is of course in certain instances open to the challenge of representing mimic rather than true heart-disease.

In addition to the therapeutic evidence, from surgery, of a possible noxious effect of gall-bladder disease on the heart, there is an increasing accumulation

of necropsy and clinical data pointing in the same direction. The various aspects of this problem have been recently so well reviewed[2] that further elaboration here is unnecessary.

The purpose of this report is to present electrocardiographic data, obtained in a small group of patients with cardiac complaints, before and after the surgical removal of gall-stones. As far as the writers can ascertain no similar study has been recorded. These patients all exhibited cardiac symptoms, chiefly anginoid in character but for the most part not of the effort type, and all were found to have abnormal electrocardiographic tracings; chiefly flat or inverted T-waves in the first two leads. Two of these six patients had no obvious manifestations of gall-bladder disease, despite the presence of gall-stones in all.

CASE I.—Mrs. K., aged sixty, first examined in 1930, complained of severe precordial pains sometimes radiating to left shoulder, usually nocturnal, rarely induced by exertion,

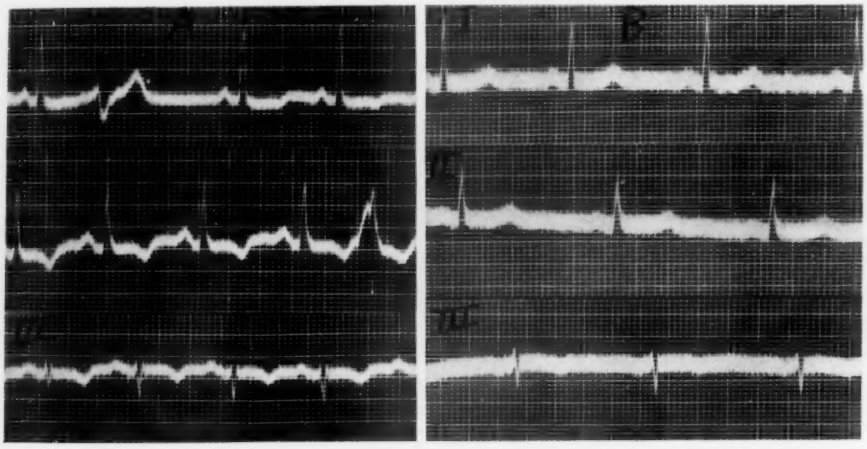

FIG. 1.—CASE I. Tracing (A) made one year prior to cholecystectomy shows T-wave inversion in all leads, which was regarded as evidence of severe myocardial damage. Tracing (B) made six weeks after operation shows no evidence of myocardial abnormality.

and present intermittently since 1925. In addition there had been in years past several violent attacks of epigastric and right upper quadrant pain most suggestive of gall-stone colic. The significant findings were: moderate arteriosclerosis, normal nutrition, normal blood-pressure, tenderness over the gall-bladder area, occasional extrasystoles, complete achlorhydria, normal blood urea nitrogen, and a non-visualized gall-bladder in the cholecystogram. The electrocardiogram (Fig. 1A) showed frequent ventricular extrasystoles, a tendency to left axis deviation and T-waves inverted in all leads. The T-wave inversion was regarded as evidence of severe myocardial disease with serious prognostic significance. The etiological factor, from the electrocardiographic changes, was presumed to be coronary artery disease.

Despite the clinical evidence of gall-stone disease it was thought that, in view of the several years of freedom from colic and in view of the apparently severe coronary artery disease, surgical intervention had better be avoided. This conservative position was dictated also by the fact that the patient's husband had died following an operation for gall-stones.

However, after a year of rest, dietary and medicinal management the patient was no better. Her anginoid seizures became more frequent and "gall-bladder dyspepsia" returned. Finally after an exacerbation of epigastric distress she became jaundiced and operation was deemed imperative.

On August 1, 1931, Dr. G. P. Müller performed cholecystectomy and choledochotomy. The common duct was found to be considerably dilated, although stones were present only in the gall-bladder. Convalescence was uneventful. Anginoid and dyspeptic symptoms disappeared. On September 16, 1931, six weeks after operation, an electrocardiogram (Fig. 1B) showed the T-waves in leads I and II to be upright and of normal amplitudes. The change from inverted to upright T-waves was interpreted as furnishing impressive objective evidence of myocardial improvement.

The patient gained rapidly in weight and strength and has since remained well. She plays golf now (aged sixty-four) and leads a normal life.

CASE II.—Mrs. S., aged thirty-eight, was first examined on September 27, 1932. She had been well until four months previously when she had a severe attack of precordial pain and fainted. She was taken home and had another attack on arrival but after a few days in bed she felt well again. She remained well, except for some vague precordial and left upper quadrant discomfort, until two weeks prior to consultation, when she was again seized with severe left upper quadrant and precordial pain which radiated into her left arm. The attack lasted for several hours and some precordial and epigastric soreness persisted for a few days. Her previous medical history included a gynecological operation and appendectomy in 1920 and an attack in 1925 of epigastric pain, nausea and fever followed by jaundice which was diagnosed catarrhal.

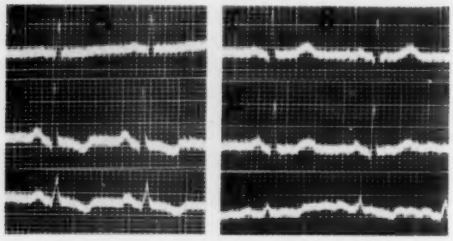

FIG. 2.—CASE II. Tracing (A) made two days before cholecystectomy shows flat T_1 and inverted T_2 and T_3. Tracing (B) made three months after cholecystectomy shows complete disappearance of abnormal findings.

Clinical examination disclosed nothing significant, but cholecystogram on September 28, 1932, showed a normally functioning gall-bladder with multiple gall-stones (Doctor Pancoast). The electrocardiogram (Fig. 2A) showed T-waves practically flat in lead I and inverted in leads II and III; the T-wave changes were interpreted as indicating the presence of myocardial damage.

Cholecystectomy was performed by Dr. I. S. Ravdin on October 1, 1932. In addition to multiple soft stones in the gall-bladder there was considerable dilatation of the common duct which was opened and drained. It contained some fine sand but no stones. The patient made an uneventful recovery and has remained perfectly well ever since; with no recurrence of anginoid or other distress. On January 3, 1933 (three months after operation) an entirely normal electrocardiogram (Fig. 2B) was obtained. It was therefore obvious that the changes in the previous tracing, which were interpreted as evidence of cardiac damage, were not due to permanent changes.

CASE III.—Mrs. T., aged forty-seven, was first seen on October 11, 1933. She was referred by Dr. F. E. Keene who at operation for fibroma uteri three years previously found gall-stones which he did not remove, because of the extent of the pelvic surgery required. She had no symptoms directly referable to gall-stones prior to this and none afterward until May, 1933, when attacks of right upper quadrant pain began. For two years, however, she had aching precordial pain at times and considerable palpitation. The precordial pain was often associated with flatulence. It was most distressing at night and was not induced by exercise. Examination revealed moderate obesity, moderate hypertension, and tenderness over the gall-bladder. Electrocardiogram

(Fig. 3A) on October 31, 1933, showed left axis deviation and T-wave inversion in leads II and III; the tracing was interpreted as indicating the presence of myocardial damage.

Cholecystectomy was performed by Dr. E. L. Eliason on November 1, 1933. There were several stones in the gall-bladder and the common duct was apparently normal. Convalescence was uneventful and the patient has had no more precordial pain since, although some flatulent dyspepsia has persisted. Before leaving the hospital a second electrocardiogram (Fig. 3B) on November 17, 1933, showed T_2 beginning to change to upright. This was regarded as a slight but definite change toward the normal. A tracing (Fig. 3C) made August 10, 1934 showed the T-waves in lead II upright and of almost normal amplitude.

Cases IV, V, and VI will not be presented in detail. Each shows a similar return toward normal of electrocardiographic deviations (chiefly T-wave inversions) within a few weeks to a few months after the surgical removal of gall-stones. Case IV, Miss M., operated upon by Doctor Eliason, was com-

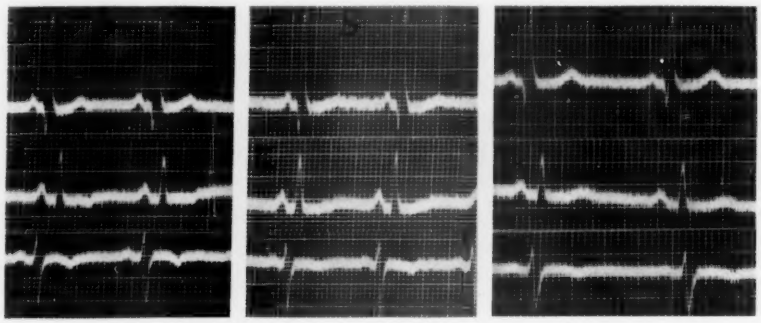

FIG. 3.—CASE III. Tracing (A) made one day before cholecystectomy: T_2 and T_3 are inverted. There is also left axis deviation and some slurring of QRS complexes. Tracing (B) made eighteen days after operation shows beginning return toward normal. Tracing (C) made nine months later shows practically normal T-waves, but no essential change in QRS complexes.

plicated by the presence of acute pancreatitis. Gall-stones were removed and drainage instituted but the gall-bladder was left. Similarly in Case V, Mrs. S., Dr. G. P. Müller was forced to content himself with cholecystostomy because this patient's heart (aged seventy-one) was severely decompensated and in chronic auricular fibrillation. The arrhythmia disappeared for two months after operation but has since recurred. Despite this the patient (now aged seventy-four) went through mastectomy for a small carcinoma without mishap last year and is now able to travel and do more than was possible for five years. Case VI, Mrs. B., duplicates the story of Case II, except that Mrs. B.'s cardiac symptoms were more severe, while her gall-bladder disease was practically symptomless until a violent attack of colic and jaundice brought matters to a head. She has been restored from a condition of apparently hopeless cardiac invalidism (violent anginal pain after eating and walking) to practically normal health; and the electrocardiographic evidences of improvement were equally striking, with change from poor to normal amplitude and from inverted to erect T-waves in leads I and II after operation.

Reversion in T-waves from pathological to normal types has been observed under the following clinical conditions: (1) During the recovery stage following exercise or myocardial anoxæmia; (2) during the recovery stage following the rapid ingestion of large amounts of cold fluid; (3) after withdrawal of drugs which had produced changes in T-waves (digitalis or drugs with digitalis-like action and the cinchona group); (4) following the restoration of normal thyroid or parathyroid function (after operation for hyperthyroidism or hyperparathyroidism[3] or appropriate treatment of myxœdema or hypoparathyroidism); (5) during the recovery stage following myocardial infarction; (6) during recovery from acute carditis or pericarditis (especially rheumatic infections); (7) following acute infections such as pneumonia or influenza which occasionally produce T-wave changes without other evidence of acute carditis; (8) following the restoration of the heart from abnormal to normal position (termination of pregnancy, cure of obesity, *etc.*), and (9) following the relief of anasarca or large fluid collections in the chest.

The cases reported in this paper obviously do not fall in any of the above categories. In the present stage of our knowledge it would be idle to speculate as to the nature of the myocardial disturbances responsible for the remarkable electrocardiographic changes observed. It seems clear from the evidence, however, that not only may gall-bladder disease injure the myocardium but that the process, at least to a certain extent, is reversible.

It is our opinion, based on these and other cases, and on a study of the literature, that the majority of patients with the coronary and myocardial types of heart-disease, or with symptoms and electrocardiographic findings suggestive of these disorders, who have associated gall-stones, are usually greatly benefited by skillful and judicious gall-bladder surgery.

It must be emphasized, however, that careful selection of cases and the services of an experienced master of gall-bladder and common-duct surgery are prerequisites. Under these conditions the procedure is remarkably safe and successful.

It must also be stated (a) that many patients with gall-stones fail to present electrocardiographic[4] or other evidences of cardiac disease; (b) that not all patients with associated gall-stone disease and heart-disease are benefited by gall-bladder surgery, and (c) that occasionally a catastrophic coronary occlusion may occur during a bout of smouldering calculous cholecystitis or choledochitis as well as during or soon after operation for relief of the latter conditions.

SUMMARY.—1. Some aspects of the relationship of gall-stone disease to mimic and to true disease of the coronary circulation are discussed.

2. The data from electrocardiographic tracings obtained before and after the surgical removal of gall-stones in six patients with symptoms suggesting disturbances of the coronary circulation are reported.

3. These electrocardiographic data, together with the clinical data, indicate an apparently beneficial effect on the heart from successful removal of gall-stones in these cases.

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HÆMORRHAGE IN RELATION TO SHOCK

EXPERIMENTAL EFFECT OF INTRAVENOUS INJECTIONS OF SALINE, GUM ACACIA, AND BLOOD ON THE RATE OF ADRENAL SECRETION RESULTING FROM HÆMORRHAGE

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The importance of hæmorrhage in producing or aggravating the condition of traumatic shock is fully appreciated. The present work was designed to throw further light upon the consequences of hæmorrhage and to evaluate the effectiveness of therapy in physiological terms.

Factors which initiate shock or accentuate the condition if present, such as cold, pain, fear, asphyxia and infection, are known to be capable of stimulating the sympathetic nervous system. Since the fundamental factor in the condition of shock is a reduced effective blood volume (Robertson and Bock,[1] Keith[2]), it was postulated in a former communication (Freeman[3]) that hyperactivity of the sympathetic nervous system of itself might lead to an actual decrease in blood volume. Experiments on cats under anæsthesia demonstrated that a condition of decreased blood volume could be produced by the intravenous injection of physiological amounts of adrenalin. In other experiments, it was shown that the spontaneous emotional overactivity associated with the removal of the cerebral cortex—the condition known as "sham rage"—resulted in a loss of blood volume leading to shock. If, however, the vasoconstrictors were paralyzed by ergotoxine or were previously removed by complete sympathectomy, even though similar amounts of adrenalin were injected or the neuromuscular expressions of rage were equally present, the blood volume was not reduced and the animals did not go into shock.

In another communication (Freeman, Morison and Sawyer[4]), evidence was brought forward that dehydration caused an increase in adrenal secretion. The relationship between dehydration and shock, which had long been recognized clinically, was therefore ascribed to sympathetic activity and its resultant decrease in blood volume.

Hæmorrhage has been found to cause vasoconstriction (Pilcher and Sollman[5]), and to be associated with an increase in adrenal secretion (Tournade and Chabrol[6]). The possibility of a vicious circle is apparent. A primary reduction in blood volume from hæmorrhage leads to sympathetic activity and vasoconstriction. This reaction is beneficial in maintaining a normal blood-pressure with an unimpaired circulation to the vital organs. Blood is diverted from the periphery to the heart and the brain. Cannon[7] has stressed this function in his concept of homeostasis. When vasoconstriction is too protracted, the blood stagnates in the peripheral vessels. A secondary decrease

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in the circulating blood volume is thereby produced, and a condition of shock may ensue. The physiological reaction to hæmorrhage, namely, the activity of the sympathetic nervous system, may prove to be the significant factor which determines the eventual outcome.

The experiments here reported were accordingly performed first to measure quantitatively the degree of sympathetic activity in terms of adrenal secretion stimulated as a result of hæmorrhage, and secondly to estimate, in terms of inhibited adrenal secretion, the relative efficacy of three therapeutic measures: intravenous saline, gum acacia, and transfusion.

METHODS.—Cats were used throughout. Unless otherwise stated, they were in active health, subsisting on the regular laboratory diet of milk and meat. The adrenal secretion was measured by determination of the rate of the denervated heart (Cannon, Lewis and Britton[8]). Since the heart becomes gradually more sensitive to adrenine for some days following denervation, a bilateral thoracic sympathectomy was performed with aseptic precautions at least one week before the experiment. At the end of that time the cat had recovered from the effects of the operative procedure.

The use of an anæsthetic such as dial, although desirable in securing a quiet preparation, prevents the full expression of the physiological processes following hæmorrhage. It was used in the first few experiments but was later discarded in favor of spinal-cord transection as described below.

On the morning of the day of the experiment, under ether anæsthesia, both vagus nerves were cut in the neck after insertion of a tracheal cannula. In this way the heart was completely isolated from the central nervous system. The spine was then transected at the second lumbar vertebra. By this procedure the hind quarters of the cat were rendered insensitive to pain and yet the chief sympathetic outflow was not affected. In the afternoon, when the animal had recovered from the anæsthesia, it was placed on a warming pad and the rectal temperature was maintained between 37° and 38° Centigrade. Since the animal was anæsthetic in the hind quarters, no further anæsthesia was necessary. A cannula was inserted into the femoral artery. The blood pressure and pulse rate were recorded on a smoked drum by means of a Marey tambour. In this way the loss of blood in determining the blood-pressure was minimized. The Marey tambour was frequently calibrated with a mercury manometer during each experiment.

A cannula was also inserted into the femoral vein for the intravenous injections. Heparin was used as an anticoagulant in some of the experiments. It was administered intravenously in doses of from fifteen to twenty milligrams per kilogram of body weight. In the other experiments the blood, as it was drawn from the femoral artery, was received into a beaker containing 2 per cent. sodium citrate solution sufficient to make a final dilution of 0.25 per cent. The blood after thorough mixing was kept over a bath of warm water until required for reinjection. All solutions used for intravenous injection were freshly prepared with triple-distilled water. The solutions and apparatus were not sterilized but the rubber tubing was treated as described by Stokes

and Busman[9] to prevent reactions. Only one reaction was encountered which could be ascribed to the intravenous injections. The acacia solution was made up by dissolving the powdered commercial product in hot water. It was filtered with suction while still hot and enough sodium chloride was added to make a 6 per cent. solution of acacia in 0.9 per cent. sodium chloride. Bayliss[10] has shown that this dilution has approximately the same viscosity as normal serum and is isotonic. Careful notes were made with regard to the general condition of the animal, the rate and character of respiration and whether the animal was quiet or restless.

Readings were taken before starting the experiment until a constant level of blood-pressure and pulse rate was obtained. The hæmorrhage was sudden, requiring only a minute or less, then fifteen to twenty minutes were allowed to elapse before instituting treatment. At the onset of bleeding the animal exhibited great restlessness with pallor of the mucous membranes of

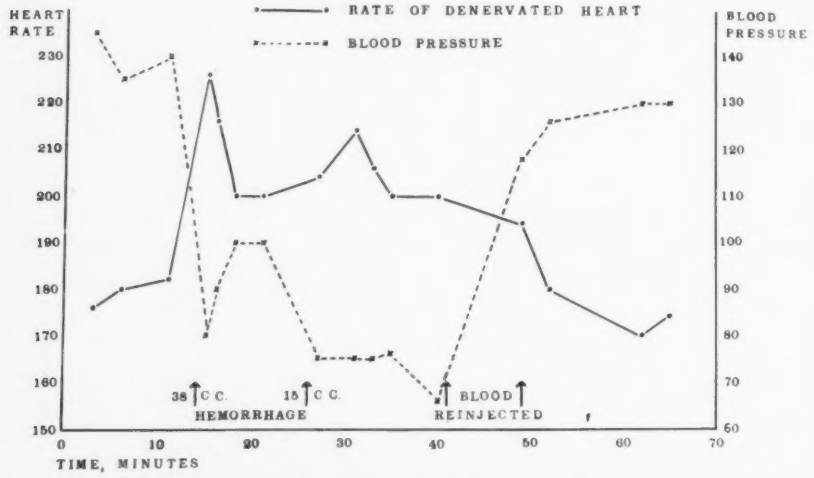

FIG. 1.—The effect of hæmorrhage and of transfusion on the blood-pressure and the rate of the denervated heart. Adrenals present. Cat, 2.8 kilograms, female.

the mouth and a rapid panting respiration which exceeded 288 per minute in one experiment. The quantity of blood removed varied from twenty to fifty cubic centimetres, or 20 to 40 per cent. of the estimated blood volume. The intravenous injections were accomplished from a burette by gravity. Between five and fifteen minutes were required for the injection of a quantity of solution equal to the amount of the hæmorrhage.

RESULTS.—The effect of hæmorrhage on adrenal secretion is demonstrated in Fig. 1. A loss of blood equivalent to 30 per cent. of the estimated blood volume led to an increase of eighteen beats per minute in the rate of the denervated heart. As the blood-pressure rose, after reinjection of the blood, the heart rate returned to a point below the pre-hæmorrhage level.

When normal saline solution was used to replace the blood lost by hæmorrhage, the blood-pressure was elevated and the heart rate was lowered immedi-

ately after the injection. As Fig. 2 shows, after a hæmorrhage equivalent to 29 per cent. of the blood volume, the heart rate increased forty-eight beats

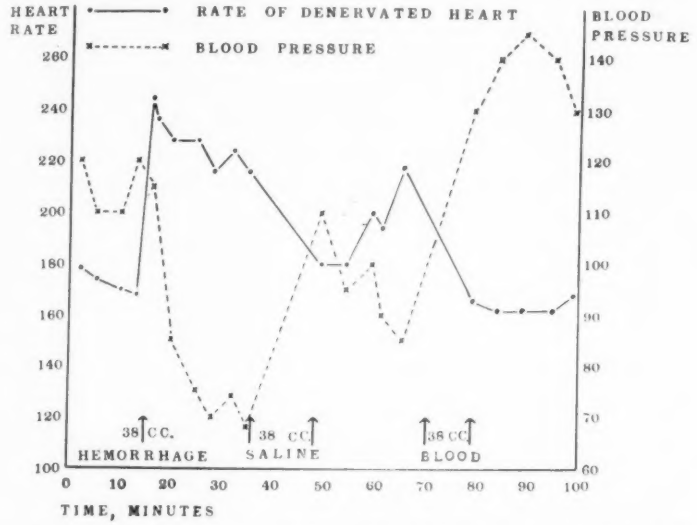

FIG. 2.—The effect of hæmorrhage and the injection of normal salt solution and blood on the blood-pressure and the rate of the denervated heart. Adrenals present. Cat, 3.2 kilograms, male.

per minute. The salt-solution injection lowered the rate thirty-four beats per minute, but within twenty minutes the heart rate had exceeded its former

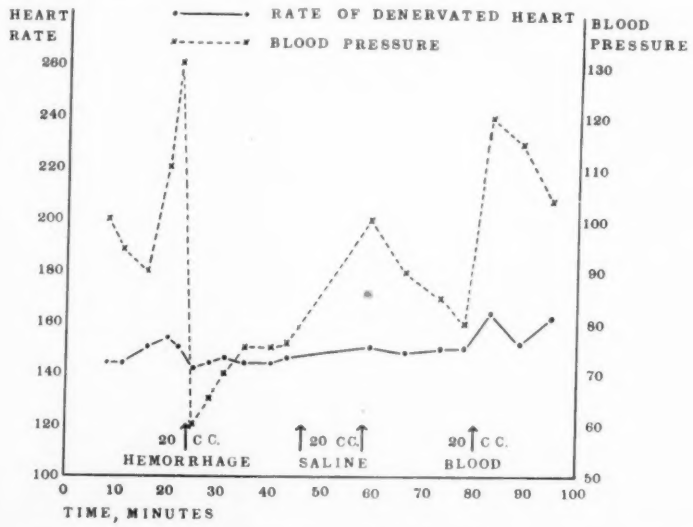

FIG. 3.—The effect of hæmorrhage and the injection of normal salt solution and blood on the blood-pressure and the rate of the denervated heart. Adrenals previously inactivated. Cat, 2.7 kilograms, female.

level. The blood-pressure elevation, in a similar manner, was not sustained. Upon reinjection of the blood, the blood-pressure rose above the original level and the adrenal secretion remained inhibited.

In order to demonstrate that the rise in heart rate after hæmorrhage was the result of adrenal secretion, an experiment was performed on a cat in which the right adrenal had been removed, the left denervated and the hepatic nerves cut at a previous operation. As can be seen in Fig. 3, instead of an increase, a slight decrease in heart rate was observed even though the blood-pressure fell to sixty millimetres of mercury. Saline injection raised the blood-pressure temporarily, as in the previous experiment, with no appreciable effect on the heart rate. With reinjection of the blood, instead of a decrease in heart rate, a slight increase was found to accompany the rise in blood-pressure.

When acacia solution was used instead of saline, the blood-pressure was elevated to the original level and the inhibition of adrenal secretion was maintained. The results given in Fig. 4 demonstrate the property which acacia

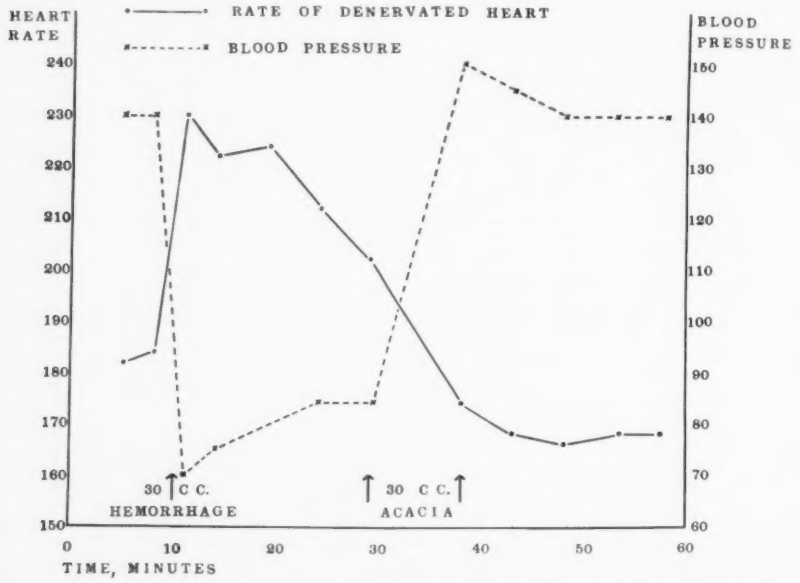

FIG. 4.—The effect of hæmorrhage and the injection of acacia on the blood-pressure and the rate of the denervated heart. Adrenals present. Cat, 3.2 kilograms, male.

solutions have to raise the blood-pressure and to reduce the heart rate after hæmorrhage. This observation was repeatedly confirmed.

In another experiment, after a hæmorrhage of only 20 per cent. of the estimated blood volume in a large, healthy, male cat, an extreme hyperactivity of the sympatho-adrenal system took place. The animal exhibited restlessness with a panting respiration which reached 288 per minute. The hairs were erect and the toe pads were moist with sweat. The results are depicted by the graph in Fig. 5. Immediately after the hæmorrhage, before the blood-pressure had fallen, the rate of the denervated heart had risen to 264, an increase of ninety-six beats per minute. Fifteen minutes later the blood-pressure had fallen to 80 and the heart rate had become stabilized at 222. Injection of normal saline equivalent to the amount of hæmorrhage now raised the blood-

pressure to 100, *but the adrenal secretion was inhibited only slightly.* The heart rate decreased from 220 to 204. In the twenty minutes following injection, the heart rate rose again to 218 while the blood-pressure fell precipitously to 70, below the pre-saline level. At this point, as shown by the arrows in the graph, acacia was given. Although the blood-pressure rose again to 100, *the adrenal secretion was still not completely inhibited.* The blood-pressure fell in the succeeding twenty minutes to 84 and the heart rate continued at 196. The blood was then reinjected with the dramatic result shown on the graph. The blood-pressure rose to 130, and the heart rate fell to 156, below the initial level. *As the adrenal secretion was now fully inhibited* the blood-pressure continued to rise in the following twenty minutes

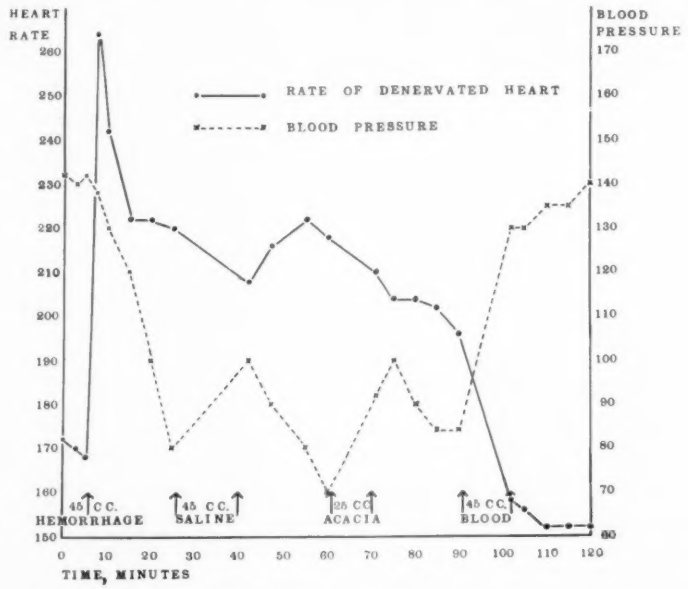

FIG. 5.—The effect of hæmorrhage and the injection of normal salt solution, acacia, and blood on the blood-pressure and the rate of the denervated heart. Adrenals present. Cat, 4.1 kilograms, male.

to 140 and the heart rate fell further to 152. A final determination taken one hour and ten minutes after the end of the record when the respirations were fifteen per minute, showed a blood-pressure of 180 millimetres of mercury and a heart rate of 158.

DISCUSSION.—The increase in adrenal secretion after hæmorrhage which has been shown in these experiments confirms the findings of Tournade and Chabrol.[6] The rate of adrenal secretion has served as an index of the intensity of stimulation of the sympathetic nervous system. Vasoconstriction, from sympathetic hyperactivity, has also been observed to accompany hæmorrhage (Pilcher and Sollman[5]). In a former communication (Freeman[3]), it was shown that vasoconstriction, from excessive activity of the sympathetic nervous system, produced an actual decrease in the circulating blood volume

probably through peripheral stasis. The following relationship between hæmorrhage and shock is therefore suggested: the primary reduction of blood volume from hæmorrhage is followed by vasoconstriction. Stasis of blood in the peripheral and splanchnic areas results from prolonged vasoconstriction and a secondary reduction in the circulating blood volume takes place. Further constriction is initiated by this secondary decrease in blood volume. A vicious circle is set up which leads to shock.

It has recently been maintained (Moon and Kennedy[11]) that the pathological picture of shock differs from that of hæmorrhage. In shock there is widespread capillary dilatation and engorgement, with œdema of the tissues and petechial hæmorrhages, while after hæmorrhage the tissues are anæmic. Blalock,[12] however, has shown that the difference in the pathological picture depends entirely upon the time factor. After rapid exsanguination, the picture of anæmia is produced. If sufficient time is allowed after hæmorrhage, the classical clinical picture of shock and a pathological picture indentical with that described by Moon and Kennedy is produced. In Blalock's experiments the blood-pressure was maintained at seventy millimetres of mercury by alternate small hæmorrhages and transfusions. After several hours "all of the animals died despite the fact that more blood was introduced than was removed." Blalock's experiments are comparable with those performed by Cannon[13] in which the blood-pressure was kept at seventy millimetres of mercury for periods of one hour by means of cardiac tamponade. The pressure in the pericardial sac was then released for five minutes and the blood-pressure was allowed to return to its former level. After the first hour of tamponade the pressure returned to normal. After the second hour, the recovery in blood-pressure was only partial, while no recovery took place in case the blood-pressure was depressed for a third hour. In Cannon's experiments as well as in those of Blalock, during the periods of low blood-pressure, the rate of adrenal secretion must have been increased (as shown by Tournade and Chabrol,[6] Heymans,[14] and the experiments here reported). This increase in adrenal secretion, associated with vasoconstriction, would lead to a diminished circulation in the areas affected by the constriction—the splanchnic area and the periphery. The circulating blood volume would be diminished and consequently the blood-pressure would fail to rise even when the obstacles to its recovery—in Blalock's experiments the loss of blood, and in those of Cannon the diminished cardiac output—were removed.

In contrast to the picture of shock produced by hæmorrhage or low blood-pressure when the sympathetic nervous system is active, are the observations of Brooks[15] on cats two weeks after transection of the spinal cord in the cervical region. The initial blood-pressure varied between seventy and ninety millimetres of mercury. By means of hæmorrhage the blood-pressure was reduced to between fifty and sixty millimetres of mercury for more than four hours and yet these cats recovered. They lived for two days after the experiment and then were sacrificed. These animals differed from those used by

Blalock and by Cannon in that the sympathetic nervous system had been separated from its central connections. They were unable to react to the low blood-pressure from hæmorrhage by an intense vasoconstriction. The blood volume presumably did not become secondarily reduced. Shock did not follow. No more convincing proof could be sought of the effect of hæmorrhage in the production of shock.

With an understanding of the mechanism by which hæmorrhage produces shock it is possible to evaluate treatment in physiological terms. *In order to be effective, the therapy of hæmorrhage must inhibit sympatho-adrenal activity before the secondary loss of blood volume through vasoconstriction shall occur.* The inhibition of adrenal secretion in turn is accomplished only by adequate restoration of the blood volume. Saline solution leaves the blood-vessels rapidly (Sherrington and Copeman,[16] Smith and Mendel[17]) so that a permanent increase in the blood volume is not to be expected. As shown in these experiments (Figs. 2 and 3), the rise in blood-pressure was only temporary, and the adrenal secretion was not fully inhibited. With acacia solution, however, the blood volume has been found to remain elevated for a much longer time (Smith and Mendel[17]); the constriction of the vessels after hæmorrhage has been shown to relax (Gesell and Moyle[18]); and in these experiments the adrenal secretion was inhibited and the blood-pressure rise was maintained (Fig. 4). Similarly after transfusion (Figs. 1 and 2) the adrenal secretion was fully inhibited and the blood-pressure likewise stayed elevated. This observation confirms the findings of Tournade and Chabrol.[6]

No conclusive evidence of the superiority of blood transfusion over acacia injection has been obtained. After minute investigation of this point Bayliss[10] states, "It is very probable that, at a certain stage, blood might be effective when acacia is useless. The margin seems to be a narrow one." A possible example of this "narrow zone" is portrayed in Fig. 5. After saline had failed to check either the fall in blood-pressure or the increased adrenal secretion, twenty-five cubic centimetres of acacia solution were administered. The blood-pressure did not fall to as low a level as it did after the saline injection. The adrenal secretion, in a similar manner, was not so intense. It is conceivable that if more acacia had been injected, complete restoration would have been accomplished. This experiment also serves to illustrate the importance of an *early* restoration of the blood volume after hæmorrhage in order to inhibit the adrenal secretion. Although the loss of blood was only 20 per cent. of the estimated blood volume, the rate of adrenal secretion was exceedingly high and the animal showed intense sympathetic stimulation. Therapy with saline and with acacia raised the blood-pressure temporarily, *but the adrenal secretion was not inhibited. The vasoconstriction persisted unchecked with a further reduction in blood volume through stasis.* With reinjection of the blood, however, the adrenal secretion was fully inhibited and the blood-pressure continued to rise.

SUMMARY AND CONCLUSIONS

The increase in the rate of the denervated heart after hæmorrhage in unanæsthetized cats is the result of hypersecretion of adrenine (Fig. 1).

If the adrenals have been previously inactivated, no increase is found in the rate of the denervated heart after hæmorrhage (Fig. 3).

Intravenous saline inhibits only slightly and temporarily the increased secretion of adrenine which results from hæmorrhage. The elevation of blood-pressure is only temporary (Figs. 2 and 5).

Intravenous injection of 6 per cent. acacia in saline solution serves more adequately to inhibit the increased secretion of adrenine after hæmorrhage. The blood-pressure elevation may be sustained (Figs. 4 and 5).

Inhibition of the adrenal secretion from hæmorrhage is well maintained by reinjection of the blood. The elevation of blood-pressure is permanent (Figs. 1, 2, 3 and 5).

The relationship between hæmorrhage and shock is pointed out from the standpoint of activity of the sympatho-adrenal system. If the hæmorrhage initiates sympathetic hyperactivity of sufficient intensity, the resultant vasoconstriction leads to a further diminution in the circulating blood volume probably through stagnation of the blood in the splanchnic area and the periphery. Such a process leads to shock (Fig. 5). With restoration of the blood volume sufficient to inhibit the sympathetic stimulation, the vicious circle is broken and recovery takes place.

Adequate treatment of hæmorrhage requires an early restoration of the circulating blood volume in order to inhibit the sympathetic activity before further loss of blood volume through stasis shall occur.

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EFFECT OF SUPERIOR LARYNGEAL NERVES ON TRACHEAL MUCUS

AN EXPERIMENTAL STUDY ON THE RELATIONSHIP

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In 1932, Roeder[1] called attention to the importance of preventing injury to the superior laryngeal nerves during thyroidectomy. Since that time we have exercised greater care in the area of the superior pole and the number of our patients who are annoyed by tracheal mucus post-operatively has decreased so markedly that a relationship between these two factors suggested itself.

If injury to the superior laryngeal nerves causes the formation of mucus post-operatively, this may be brought about by any one or all of three possible mechanisms. Anæsthesia of the mucous membrane may be produced by injury to the nerves so that large quantities of mucus may collect before being coughed up. The injury may act as a direct stimulant to mucous secretion through the peripheral end of the nerve. It may act as a reflex stimulant through the central end of the nerve. The first of these mechanisms has been established by laryngoscopists who have, from time to time, been able to demonstrate anæsthesia of the mucous membrane in the area supplied by the superior laryngeal nerves when these have been injured. The remaining two mechanisms have been the subject of this investigation.

Method.—Kokin[2] working in Pavlov's laboratory in 1896 reported that drops of mucus could be seen collecting on the exposed trachea of the dog when the appropriate nerves were stimulated. This method of observation, however, has proved to be a most unsatisfactory one in as much as drops of mucus could be seen collecting on the mucosa when the nerves were not stimulated.

A more accurate method of observing the secretion of tracheal mucus was recently described by Florey and Wells.[3] Briefly it consists of enclosing a small segment of trachea between two cannulæ. The lower cannula is attached to an horizontal manometer. The system is filled with olive oil and the upper cannula is closed off. Thus, changes in the volume of the tracheal segment are measured by the changes in the level of the olive oil in the manometer.

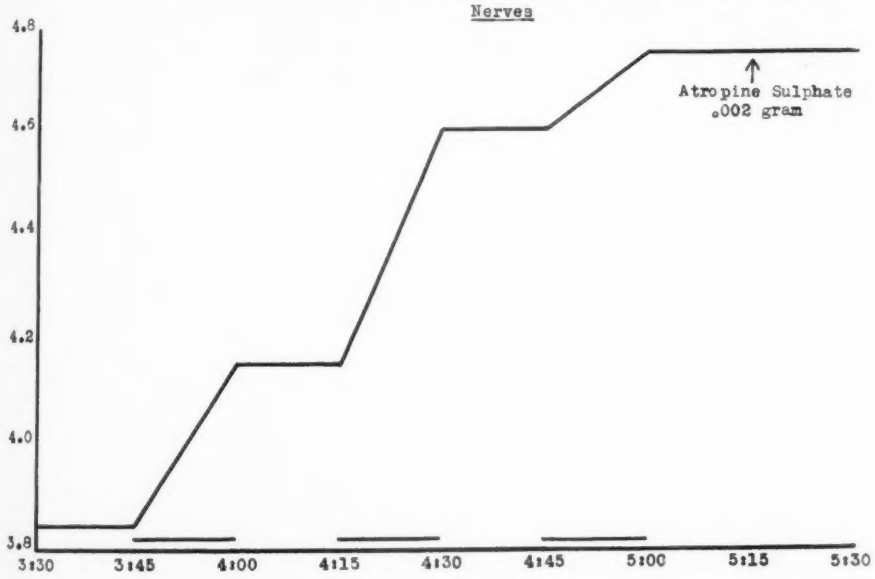
Using this method Florey, Carleton and Wells[4] demonstrated the secretion of tracheal mucus upon stimulation of the peripheral ends of the recurrent laryngeal nerves. This was confirmed by the fact that pilocarpine gave a similar but more powerful response. They also showed the presence of a reflex arc by the fact that mucus was secreted after stimulation of the central end of one cut vagus. All of these secretory responses could be prevented by

atropine. These workers did not study the superior laryngeal nerves because these nerves did not supply that portion of the trachea which was included in the tracheal segment which they observed.

This method has been adapted to the present study of the area supplied by the superior laryngeal nerves by doing a laryngofissure and placing the upper cannula through the vocal cords where it is fixed with a purse-string suture. There is thus formed a laryngotracheal segment containing at least part of the mucosa innervated by the superior laryngeal nerves. This method gives a considerably longer segment with which to make observations and at the same time reduces the likelihood of damaging the blood supply to the segment.

When such a set-up was left undisturbed, the level of the olive oil remained remarkably constant over a period of several hours. Respiratory and swal-

FIGURE I Stimulation of Peripheral Ends of Recurrent Laryngeal Nerves



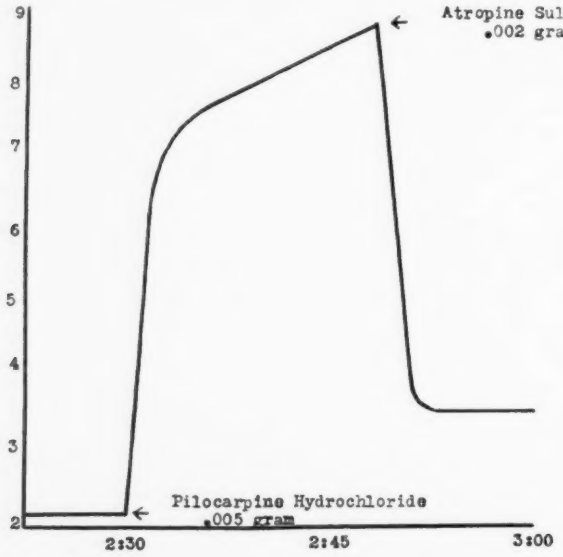
lowing movements caused only a slight excursion in the level of the oil. Movements of the body in relation to the cannulæ were found to cause permanent changes in the level of the oil and had to be guarded against by proper anæsthesia. Under various conditions there was contraction of the tracheal musculature, causing a rise in the level of the oil which had to be differentiated from that due to the secretion of mucus. In conducting the experiments it was necessary to take great care to preserve the blood supply to the tracheal segment and to keep the tracheal segment as well as the various nerves moist and warm. A high frequency electrocoagulation unit was used to coagulate all bleeding points and thus prevent any blood from getting in the tracheal segment during the exposure. Cats have been used as the experimental animal. Intraperitoneal sodium amytal, fifty milligrams per kilogram of body weight, was used for anæsthesia.

Experiments.—Fig. 1 confirms the observation of Florey and his associates that stimulation of the peripheral ends of the recurrent laryngeal nerves will cause the secretion of tracheal mucus.

The two nerves were stimulated alternately one-half minute each for fifteen minutes. A weak faradic current was used. With each stimulation there was an immediate slight rise in the level of the olive oil due to contraction of the tracheal musculature, but this disappeared when the stimulus was removed. During each fifteen-minute period of stimulation there was a gradual rise in the level of the olive oil. When the trachea was opened a plug of clear mucus was always found. In other experiments without nerve stimulation no mucous plug was found in the trachea.

The observation that pilocarpine will give a similar but more powerful response is confirmed in Fig. 2.

FIGURE II The Effect of Pilocarpine on Mucus Secretion

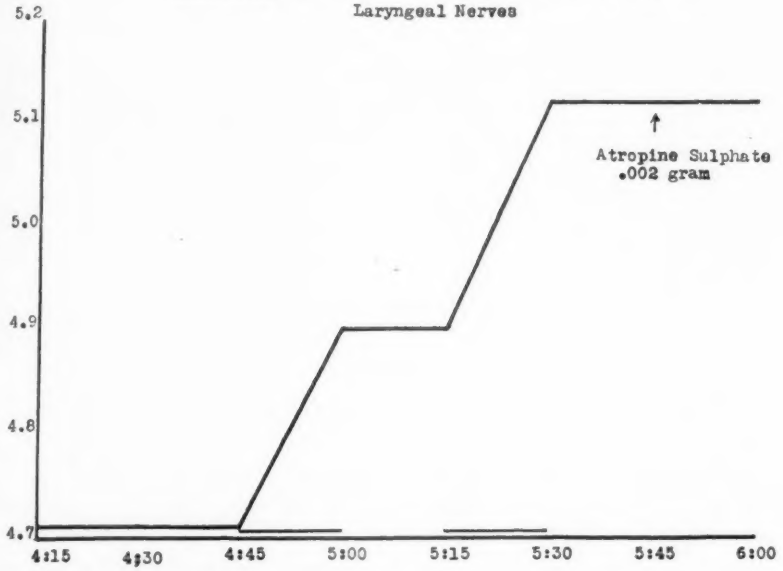


When pilocarpine was given intravenously there was an immediate rapid rise in the level of the olive oil due to contraction of the tracheal musculature. When atropine was given, the level of the oil fell as the musculature relaxed. The difference between the final level and the level before pilocarpine was given represents the amounts of tracheal mucus secreted. This was always confirmed also by the presence of a large plug of mucus when the trachea was opened. When atropine was given without having first given pilocarpine there was little or no fall in the level of the oil.

When the central end of one cut vagus was stimulated there was a very slight rise in the level of the olive oil and a very small plug of mucus was found in the trachea.

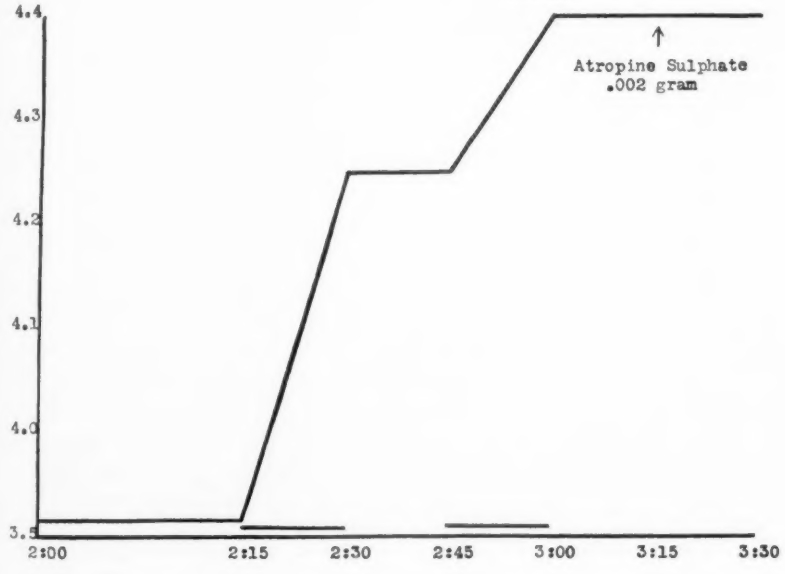
In addition to these experiments, investigations were carried out on the

FIGURE III Stimulation of Peripheral Ends of Superior Laryngeal Nerves



superior laryngeal nerves by means of the laryngotracheal segment. Data was obtained which demonstrated that the superior laryngeal nerves have an action

FIGURE IV Stimulation of Centran ends of Superior Laryngeal Nerves



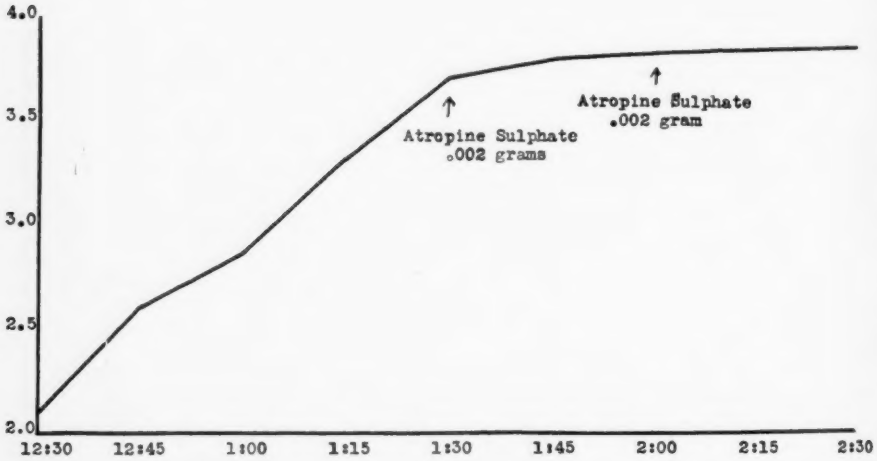
on the tracheal mucous membrane similar to that of the recurrent laryngeal nerves. In Fig. 3 the result of the stimulation of the peripheral ends of the

superior laryngeal nerves is shown. There was a definite rise in the level of the olive oil during each period of stimulation and a plug of mucus was found in the trachea.

Likewise the data given in Fig. 4 demonstrate the presence of a reflex arc since there was a rise in the level of the olive oil upon stimulation of the central ends of the cut superior laryngeal nerves. Here also a plug of mucus was found when the tracheal segment was opened.

These experiments demonstrate the presence of an efferent pathway as well as part of an afferent pathway. The question arises as to whether the afferent pathway extends to the nerves ending in the mucosa and whether these two pathways are involved as a reflex arc in the physiological secretion of mucus. When an irritating substance comes in contact with the tracheal

FIGURE V Secretion of Mucus Due to Blood in the Trachea - Inhibited by Atropine



mucosa it may cause a secretion of mucus by two mechanisms, first by direct irritation of the mucous glands, and second by means of the reflex arc referred to above.

The first of these mechanisms has been shown to exist by Florey and his associates. In their experiment, although the nerve supply was completely blocked by atropine, mucus was secreted when irritating substances such as mustard oil came in contact with the mucosa. However, they failed to demonstrate the second mechanism, namely, the secretion of mucus through the reflex arc. They tried to produce a curve of a certain steepness which could be greatly decreased by atropine, thus showing that part of the secretion was produced through reflex stimulation. However, the strong irritants which they used caused a contraction of the tracheal musculature and prevented observations on mucous secretion.

These observations can be made, however, by using a mild and more nat-

ural irritant such as blood. In preparing the tracheal segment a film of blood was allowed to run over the mucous membrane before the cannulæ were connected. Following this there was a gradual and persistent rise in the level of the olive oil over a period of two hours. This was interpreted as being due to a secretion of mucus in as much as there is no reason to believe that blood can cause muscle to contract in this gradual manner. When the trachea was opened a large plug of bloody mucus was found. This experiment was repeated and at the end of one hour of continuous and steady rise of the olive oil, atropine was given intravenously as shown in Fig. 5. The secretion of mucus was greatly reduced but not entirely stopped. This result has been repeatedly obtained and suggests that there is a reflex arc involved in the secretion of mucus which may be interrupted by atropine.

SUMMARY

It is apparent from the work of Florey *et al.*, and from the data reported in this paper that:

1. Stimulation of the peripheral ends of the recurrent and of the superior laryngeal nerves will cause a secretion of tracheal mucus.

2. A more abundant secretion is produced by pilocarpine.

3. Stimulation of the central end of the vagus or of the superior laryngeal nerves will cause a reflex secretion of mucus.

4. Direct stimulation of the tracheal mucosa will cause a secretion of mucus partially by direct irritation of the mucous glands and partially by stimulation of the mucous glands through a reflex arc.

5. All of these above secretory mechanisms may be interrupted by atropine except that of direct irritation of the mucous glands.

6. The demonstration of the above facts together with the clinical observation presents fairly good presumptive evidence that there is a definite relationship between injury to the superior laryngeal nerves during thyroidectomy and the formation of post-operative tracheal mucus.

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ACTION OF GLUCOSE ON EMPTYING OF STOMACH

EFFECT OF VARYING CONCENTRATIONS IN BOTH NORMAL STOMACHS AND AFTER VARIOUS GASTRIC OPERATIONS

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The effect of various substances upon the emptying time of the stomach has been commented upon in the older physiological literature but the significance of these early studies has been but little stressed. Carnot and Chassevant[1] studied the effect of varying concentrations of glucose and sodium chloride and noted that isotonic solutions left the stomach faster than water, hypo- or hypertonic solutions. Due to the diluting action of gastric juice and saliva and the mobilization of fluid from the body stores, hypertonic solutions tended to become isotonic. This preparation of substances for acceptance into the intestine had been noted and commented upon by earlier investigators.

In 1925, Cori[2] published data which purported to show that regardless of the concentration of sugars placed in the stomach of the rat, the rate of absorption remained constant for 100 Gm. of body weight. In 1933, we[3] published results on the absorption of varying concentrations of glucose from isolated loops of the small intestine which did not agree with the Cori hypothesis. Subsequent investigations[4] on the effect of the stomach and the duodenum on such solutions offered a simple explanation for Cori's results. In short, we noted that when hypertonic solutions of glucose were placed in the stomach and allowed to remain for one hour, there was a tendency for the volume in the stomach to increase and the concentration to decrease. The concentrations of glucose found in the intestine at the end of an hour were approximately isotonic or lower. These findings suggested to us that the hypertonic solutions of glucose left the stomach slowly enough to permit of changes in the fluid concentrations to those which would be acceptable to the intestine. That this control was due to the activity of the pylorus reacting to the stimulus of small amounts of glucose in the duodenum in concentrations higher than isotonicity was suggested by the fact that, although the concentration of glucose in the stomach remained high in many instances, those found in the jejunum and ileum were always at or below isotonicity. The small amounts of hypertonic glucose passing into the duodenum presumably offered the stimulus which prevented the passage of larger quantities from the stomach. A similar view was presented by Shay and Cohen[5] regarding the

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control of the pylorus. These authors presented evidence which indicated that the emptying time of the stomach is influenced by varying concentrations of hydrochloric acid or sodium bicarbonate. That this mechanism which retards the emptying of the stomach is not resident in the stomach is indicated by the fact that the solutions were equally as effective when placed directly into the duodenum through a tube. Shay and Cohen's studies were carried out on human subjects using fluoroscopic observation of a barium mixture as a means of determining the rate of emptying of the stomach. Our experiments were carried out on dogs using an entirely different criterion for the determination of the emptying of the stomach contents. The results of these two sets of experiments while obtained by different methods were similar in that both indicated that substances not acceptable to the duodenum retard the passage of material from the stomach by action on the duodenum.

In patients or animals which have had operations such as a gastroenterostomy or a Billroth I operation, the pylorus is no longer active in causing retardation of the emptying of the stomach due to the larger and less contractile opening into the intestine. It seemed of interest to determine in these the effect of various concentrations of glucose on the emptying time of the stomach by a technic similar to that used in the normal animals. Since the above operations are, as a rule, considered to be "dumping operations," the results might be expected to be different. After such operations the emptying time of the stomach is not dependent on the pylorus and there is no condensation of muscle fibres at the stoma such as are found in normal sphincters, to retard emptying by active contraction. In fact, closure by contraction is actually prevented by the size of the opening and by the cicatrix at the line of suture. Any restraining influence, if such can be demonstrated, must be brought about by contraction of the small intestine.

Method.—The method used in this investigation was identical to that used in our experiments[4] in dogs with an intact gastro-intestinal tract except that in this series the animals had had an anterior gastroenterostomy, a Polya, or Billroth I operation more than a month before the experiment was carried out. Glucose solutions of varying concentrations were introduced into the stomach of the unanæsthetized animal by stomach tube and allowed to remain there for a period of one hour. All animals in which vomiting occurred were discarded. The dogs were then anæsthetized by the intravenous administration of sodium amytal. The abdomen was rapidly opened, clamps were placed on the œsophagus, duodenum, on the jejunum on either side of the enterostomy when necessary, and at the terminal portion of the ileum. In this way the fluid was prevented from passing from one portion of the gastro-intestinal tract to another after death. The stomach and small gut were then removed and the fluid content of each portion of the tract was collected separately, carefully measured and analyzed for glucose by the Benedict[6] method. The removal of the specimens from the animal never required more than ten minutes. No attempt was made to wash various portions of the tract so as to measure accurately the amount of glucose absorbed.

TABLE I

DOG	Amt. in cc.	Conc. in per cent.	Stomach Amt. out cc.	Stomach Conc. out per cent.	Duodenum Amt. out cc.	Duodenum Conc. out per cent.	Small Intestine Amt. out cc.	Small Intestine Conc. out per cent.	Jejunum and Ileum Amt. out cc.	Jejunum and Ileum Conc. out per cent.
Normal Animals										
982	200	58.8	295	25.0			40	3.6		
773	200	57.6	250	24.4			235	4.4		
757	200	38.5	250	19.3			47	9.0		
744	200	22.3	150	11.4			56	4.2		
832	200	22.2	150	13.0			64	3.4		
415	200	10.2	176	5.0			30	2.3		
940	200	7.1	20	2.8			10	1.7		
1,004	200	5.7	100	3.4			35	1.6		
811	200	5.4	19	2.3			5	1.7		
Gastroenterostomy										
34	200	56.8	250	9.6			210	4.0		
64	200	56.8	375	11.1			150	4.4		
955	100	46.8	16	7.7			50	4.9		
804	200	24.6	150	6.4	70	6.4			125	3.4
471	200	24.6	475	5.8	200	4.7			4	
488	100	16.2	300	2.8	52	2.8			5	
919	100	16.2	138	6.7	28	4.0			15	2.3
751	200	16.2	255	3.3	55	3.4			20	2.8
921	100	11.6	75	1.1			53	1.1		
662	200	11.6	420	1.0			55	0.8		
968	200	11.6	90	1.5			25	1.1		
Billroth I										
1,007	200	23.4	224	10.0			100	2.8		
125	200	50.0	425	14.7			235	4.5		
Polya										
877	200	24.6	300	6.2	40	4.5			75	3.3
1,004	200	24.6	200	5.3	14	3.4			160	4.0
944	200	23.8	350	6.3	21	2.9			85	5.9
712	100	24.6	140	6.9	5				20	5.3

RESULTS.—The results of these experiments as well as representative data from experiments on normal dogs are presented in Table I.

In all animals the concentrations of glucose recovered from the small intestine after an hour period were in all instances at or below isotonic levels. The concentrations of glucose found in the stomachs of normal animals were in general higher than those found in the stomachs of animals which had been operated on. The volume of fluid remaining in the stomach in the latter series varied widely, but in general was greater than that found for similar concentrations in the normal group. In the animals which had a gastroenterostomy or a Polya operation the fluid from the small intestine was divided into the portion which was recovered from the duodenum and the portion from the jejunum and ileum. In the animals with a gastroenterostomy the concentration of glucose recovered from the duodenum was higher than that found in the remainder of the small intestine. This relationship was reversed in three of the four animals which had a Polya operation.

In those animals which had a gastroenterostomy, the duodenum was in all instances noticeably dilated so that when the abdominal cavity was opened the duodenum was easily identified by its greater size. Associated with the greater size of the duodenum in the animals with a gastroenterostomy there was also a greater amount of fluid in the duodenum.

DISCUSSION.—The work of Shay and Cohen[5] well illustrated that the passage of material from the stomach is affected markedly by the material which is leaving the stomach. Similarly, our earlier work[4] indicated that the emptying time of the stomach was changed by variations in the concentration of glucose introduced into the stomach. Just how much the active contraction of the pylorus has to do with this mechanism is not evident from these reports. The work of Gianturco,[7] in addition to showing the effect of various substances on the emptying time of the stomach, also indicates that the pylorus contracts actively to prevent the passage of material from the stomach. By means of X-ray cinematographs with markers outlining the stomach and intestines the position of the barium column could be better followed. In the case of hypertonic glucose solutions introduced with barium the head of the barium column was seen to go as far as the cap of the duodenum when the emptying of the stomach contents was abruptly stopped, the pylorus contracting actively.

In the experiments reported in the present paper the activity of the pylorus was not a significant factor in preventing the evacuation of the gastric contents since in the animals which had been operated on there was an opening between the stomach and intestine which had little if any contractile power. Any slowing of the emptying time which was noted following the administration of the higher concentrations of glucose must depend on contraction of the intestine below the enterostomy stoma.

Additional evidence that the emptying time of the stomach through a gastroenterostomy is slowed by violent active contraction of intestine is afforded in work on man and dogs which is to be reported later in collabora-

tion with Dr. Eugene Pendergrass. A patient given a glucose barium meal several months after a gastroenterostomy had been performed emptied a small amount of material from the stomach within a few seconds after ingestion. Immediately thereafter the small intestine below the enterostomy contracted and remained firmly contracted for a period of ten minutes.

These observations indicate the futility of comparisons of the emptying time of the stomach when röntgenologists use different vehicles for the barium suspension. Barium mixtures which are made up with malted milk, chocolate or other material to make them more palatable will empty more slowly than the ordinary barium water mixture, and both will empty more slowly than when isotonic solutions are used for the barium suspension. This will be true whether the examination is made on a normal stomach or on one which had been subjected to a gastroenterostomy.

The dilatation of the duodenum seen in the animals which had had a gastroenterostomy performed was striking, but the explanation for this phenomenon is not evident from our experiments. A possible explanation lies in the fact that the duodenum in our animals was subjected to two streams of material, one through the pylorus, the other through the enterostomy. This explanation is made more plausible by the fact that the animals which had an enterostomy had more fluid in the duodenum than those with a Polya operation. Since in the Polya operation the fluid must have reached the duodenum through the enterostomy alone, it is to be expected that less fluid should be found in the duodenum. That the increased fluid was not dependent on the secretion of fluid into the duodenum is evidenced by the fact that the glucose concentrations found in the duodenum of the animals with gastroenterostomy were higher than those found after the Polya operation. That the dilatation of the duodenal loop is not a finding peculiar to the dog is indicated by the fact that Doctor Pendergrass[8] has noted a similar condition in cases of gastroenterostomy in the human. The lower concentrations found in the stomach at the termination of the experiment in the dogs which had been operated on as compared to the normal dogs may in part be due to some regurgitation of more dilute fluids through the stoma from the small intestine.

While differences in the action of glucose solutions of varying concentration on the normal gastro-intestinal tract as compared with stomachs after operation have been found, the fact that such small differences were noted in the behavior of the stomach after operation and the normal stomach is surprising. In both instances hypertonic glucose solutions leave the stomach less rapidly than approximately isotonic solutions. That many factors may influence the emptying of the stomach has been shown by the work of Hedblom and Cannon[9] and of Carlson and co-workers.[10] That variations in concentration of material contained in the stomach and intestines can influece the emptying time of the stomach has been adequately shown by earlier reports (Carnot and Chassevant[1]). That glucose in hypertonic concentrations can influence the emptying time of the operated stomach after a gastric operation is definitely shown by the data presented here.

CONCLUSIONS.—The results of these observations indicate that operations on the stomach such as the Billroth type are not "dumping operations" as they are often considered. Glucose solutions taken into the stomach do not drop immediately into the small intestine but are retarded in their passage by the activity of the intestine. The passage of material from the stomach after operation in clinical cases is influenced undoubtedly by the type of food ingested, there being little or no difference in man or dog. Studies to determine the effects of various foods on the emptying time of the stomach both normal and after gastric operations are being carried out at the present time in conjunction with the Department of Radiology of the Hospital of the University of Pennsylvania. It is hoped that these studies will give us a better insight into the mechanics of gastric emptying in patients with various types of short-circuiting operations. The type of examination usually given these patients affords evidence as to whether the stoma is patent, unless the Roentgen studies are performed too soon after operation, but does not reveal the mechanics of emptying under conditions to which the bowel is daily subjected by the average or special diet which the patient is taking.

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DOCTOR WILLIAM HUNTER OF NEWPORT

By E. B. Krumbhaar, M.D.
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William Hunter of Newport is "covered" by standard works on American medical history in a scant dozen lines to the effect that he was born in Scotland in 1729, a relative of the famous John and William Hunter, studied at Edinburgh under Munro and at Leyden, came to Rhode Island about 1752, gave early anatomical lectures at Newport, 1754–1756, possessed the largest medical library in New England and died in 1777. Most of this information comes from Thacher[21] and several of the items are doubtful or incorrect. The unusual interest attaching to his career as well as his important position in the development of American medicine suggested to me, while studying the early history of anatomy in this country,[7] that his life should be given fuller treatment. The same idea had already occurred to Dr. H. B. Jacobs of Baltimore; but though he never brought his studies to fruition, he has kindly furnished me with much pertinent material.

At the very outset of Hunter's life, we encounter difficulties. He was thought by his descendants to have been born in 1729 in Edinburgh; some authorities assign his birth to the year 1730 or 1731. This last, however, would have made him extremely young to have been, as appears later, at the battle of Culloden, 1746. As his tombstone states that he was in his forty-seventh year on January 30, 1777, this would indicate that he was probably born in 1730, and 16 is not too young for a surgeon's mate. It has always been a tradition in his family (and one held by his direct descendants living in Newport today) that he was a cousin of the famous brothers William and John Hunter of Long Calderwood, in Lanarkshire. Hunter himself is said to have said that he was their cousin. Tradition has it also that he was a descendant of the Hunterston* Hunters; but it must be accepted that definite evidence of his birthplace in Scotland, relationships there, and year of birth are lacking. On the other hand, a family resemblance has been noted, especially between John Hunter's portrait bust and William Hunter, the son of the subject of this sketch. John Hunter's descendants in London also have the tradition of the Hunterston descent but have not been able to prove it. Also there is said to be no evidence in the Hunterson records of a son having gone to America. When William Hunter's widow went to England in 1786, expect-

* In 1903, Hunterston Castle was still standing in the parish of West Kilbride, Ayrshire, one and one-half miles from Southannan, though then used as a farmhouse (see D. Y. Cameron's etching in "Two Great Scotsmen," G. R. Mather, Glasgow, 1903). This branch of the Hunter family seems to have been established there in the early thirteenth century. The famous brothers are said to have been descended from Patrick, a seventeenth-century Hunter of Hunterston, through his third son, Francis.

ing to return the next year, she left her house in charge of Charles Feke, her husband's apothecary. Later deciding to remain in England and wishing to rent the house, she told him to burn a trunkful of letters. This source of vexation to the would-be genealogist, unfortunately so frequently repeated, doubtless accounts for many paucities of detail in William Hunter's life, and is accentuated by his death during the troublous times of the Revolution and the devastation of Newport shortly after.

We next hear of the young William Hunter at the fated field of Culloden, where as a mere boy he was a surgeon's mate, "Dr. Middleton of New York being his principal" (Thacher's[21] and Mrs. William Hunter's diary[5]). This of course refers to Peter Middleton,* a graduate of St. Andrews, who must have come to this country shortly after "the '45," as it was in 1750 that he assisted Dr. John Bard in New York in making the well-known "dissection for anatomical purposes." Nothing further has been ascertained about William's relationship to William and John Hunter. The younger William apparently suffered no evil results from his Jacobite venture, as he shortly afterwards began the study of medicine at Edinburgh under the elder Monro (primus, 1697–1767). His great grandson found books at Edinburgh with his name inscribed in them, but more definite evidence of his sojourn there is not yet forthcoming.† It seems probable that he studied at Leyden, and while his name is not registered as a matriculant, he may well have pursued special studies there without registration. He is said to have studied with his cousin, the famous John; but this is unlikely as John arrived in London from Lanarkshire absolutely untrained scientifically in 1748 and there is no indication that our William studied in London. This statement more properly refers to the lawyer-son William (born 1774), who first studied medicine, and could have worked with John, as John did not die till 1793. The younger Hunter's daughter, Mrs. Birckhead, stated: "His mother (*i.e.*, the wife of the subject of this study), a widow at that time, was a stranger in London and must have turned to the latter to help in her son's advancement. As it happened, the boy did not like medicine and turned to the law, probably to the disgust of Dr. John Hunter."

William Hunter apparently came to this country in 1752, a young man of twenty-two or twenty-three, bringing "a valuable library" with him. This

* One of the founders of the King's College Faculty of Physic, the second oldest in this country, Middleton was their first Professor of the Theory of Physic (not of Pathology and Physiology, as frequently stated).

† Dr. John D. Comrie of Edinburgh has kindly searched the Scottish records and reports that Hunter's name is not mentioned in Monro's class list from 1746 to 1749. Unfortunately this record was not kept from 1750 to 1767. He further says: "It can be said definitely that he did not graduate at Edinburgh, and that he was not a member of the Royal Medical Society, but he may have taken a licence from the Royal College of surgeons. His name is not in the Bibliotheca Britannica." In regard to Culloden, Doctor Comrie states that Hunter's name is not in the list of Jacobite prisoners, as was perhaps to be expected, and naturally is not in Macnaughton's "Heroes of the Forty-five," or Johnston's "Roll of Officers in the Medical Service of the British Army."

FIG. 1.—Portrait of William Hunter of Newport. Painted by Cosmo Alexander, 1769. This is the original from a copy of which the reproduction was made in Ann. Med. Hist., vol. 4, p. 284, 1922.

FIG. 2.—Portrait of Mrs. Hunter (Deborah Malbone) and her daughter. This was probably the oldest daughter, Elizabeth, born 1762. It is stated that this was painted in 1767, but it is more probable that it, like the husband's, was done in 1769. The originals of this and the portrait of Dr. Hunter (Fig. 1) are now in the possession of a descendant—one of the children of Mrs. Wm. H. Birckhead.

was the nucleus of a collection which is said to have been the largest in New England at the time of its dispersion after his death. Some of these books were given by his son to the library of Brown University, where they are still to be found, though not preserved as a collection. Among the titles were: J. Allen: "Synopsis Universæ Medicinæ" (1730); Alpinus, "De Medicina Methodica" (1719) and "Medicina Aegyptiorum" (1719); C. Benedictus, "Tabidorum Theatrum" (1656); Boerhaave, "Disputatio Medica" (1702); Fr. Hoffmann, "Opera" (6 vols., 1748); Mangetus, "Bibliotheca Pharmaceutica-Medica" (1703); Spigelius, "Opera quae Extant Omnia" (1645); J. J. Wepfer, "Observationes anatomicae ex Cadaveribus eorum quos Sustulit

FIG. 2A.—Collection of William Hunter Books at Brown University and William Hunter's Bookplate.

Apoplexia" (1724); Th. Willis, "Cerebri Anatome (1666) and 80 Leyden dissertations. In the Inventory of Hunter's effects are mentioned "Alston's Lectures in 2 Volums (sic) 13/6, Macbride 15/9, Elabratory laid open 5/6 Persivals Essays in 2 Volumes 9/ White, on pregnant women 4/6 London Practice on Physick 1/6 Mackburg on y^e Bile 3/6 Whites Cases 3/ A new dispensatory 6/9 2 old ditto 4/6 Eddenborough Letters 3/6 Quincy's Lexicon 2/6 Clarke's observations 2/3 Family Physician 4/6 Medical consulta^m 3/4 Eustachu (*sic*) Plates 9/. Smella's ditto 21/ Monros Anatomy 2/3 Johnson Dictionary folio in Two Volumes."

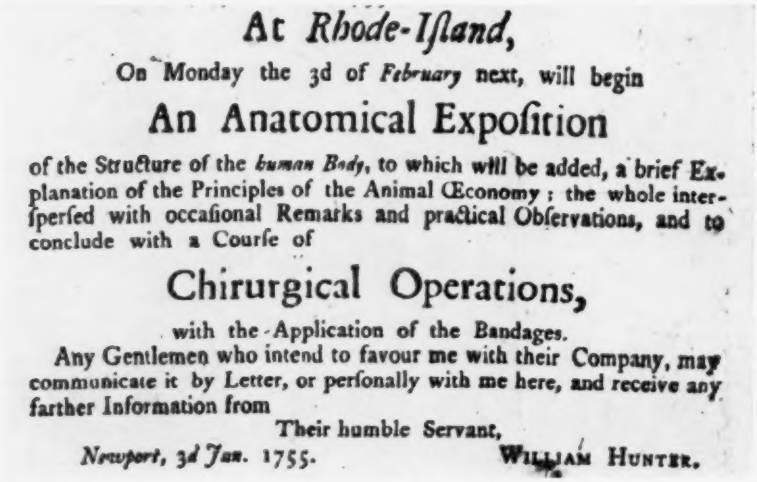
Arriving in this country he settled in Newport (founded by a physician, John Clarke), a thriving city that had already acquired considerable

of Dr. Hunter (Fig. 1) are now in the possession of a descendant—one of the children of Mrs. Wm. H. Birckhead.

wealth, situated in a prospering colony.[17] This prosperity was largely due to the charter obtained from Charles II by Roger Williams and Clarke, which granted more civil and religious freedom than obtained in the other provinces. John Brett, Thomas Moffatt and John Haliburton were among the well-known medical men who came from the mother country to Newport about this time. Hunter quickly attained a position of prominence in Newport; graduates of European medical schools were none too common in the colonies at that time, and he was the first "male accoucheur in the colony."[18]

In 1755, only three years after his arrival, Hunter advertised in the Boston *Evening Post* of January 20, 27 and February 3, 1755 (as there was no newspaper in Newport at that time) his intention of giving a series of lectures on anatomy and surgery (Fig. 3).

The celebrated Benjamin Waterhouse said concerning these lectures:



At *Rhode-Island*,

On Monday the 3d of *February* next, will begin

An Anatomical Expoſition

of the Structure of the *human Body*, to which will be added, a brief Explanation of the Principles of the Animal Œconomy: the whole interſperſed with occaſional Remarks and practical Obſervations, and to conclude with a Courſe of

Chirurgical Operations,

with the Application of the Bandages.

Any Gentlemen who intend to favour me with their Company, may communicate it by Letter, or perſonally with me here, and receive any farther Information from

Their humble Servant,

Newport, 3d *Jan.* 1755. WILLIAM HUNTER.

FIG. 3.—Advertisement of Hunter's lectures in the Boston *Evening Post*, January 20, 1775 (photostat Boston Public Library).

"About the year 1756, Dr. William Hunter gave at Newport, R. I., the first anatomical and surgical lectures ever delivered in the twelve Colonies. They were delivered in the Court House, two seasons in succession, by cards of invitation, and to great satisfaction. His collection of instruments was much larger than any professor exhibits at this day. Doctor Hunter was a man of talents, well-educated at Edinburgh, and a gentleman of taste in the fine arts." (Peterson.[15]) The manuscript of these lectures was said by Thacher in 1828 still to be in existence according to the N. Y. Medical Repository, but I have not been able to locate either the manuscript or the reference. That these lectures were actually given, and well attended, is proven by the existence of at least two tickets of admission on the familiar playing card backs (No. 61, Mr. William Vernon and No. 101, Mr. Brindley) (Figs. 4 and 4A). How many more took advantage of this systematic instruction, the apprentice system being the only other available method of acquiring medical knowledge, is of

course not known. Neither is it known how long the lectures continued. The usual statement is that they were given 1754–1756 (Thacher), but from the

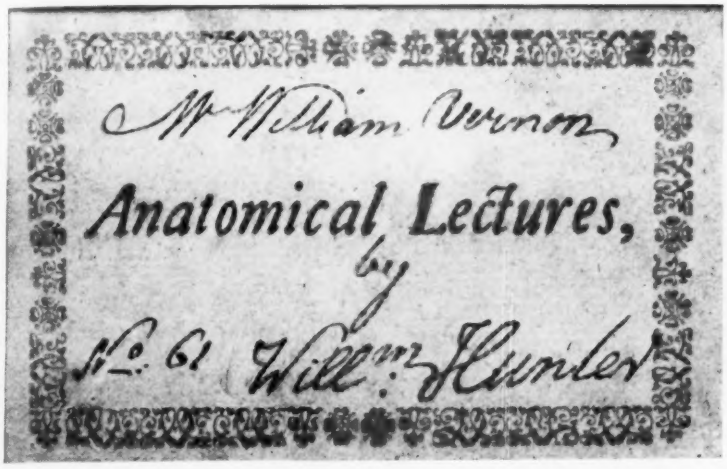


FIG. 4.—Mr. William Vernon's ticket to Hunter's lectures, printed on the back of a playing card.

above advertisement it would seem that they were not begun until 1755, Waterhouse's second season presumably being 1756. The lectures were given in the Old Colony (State) House (Fig. 5) and apparently attended by many

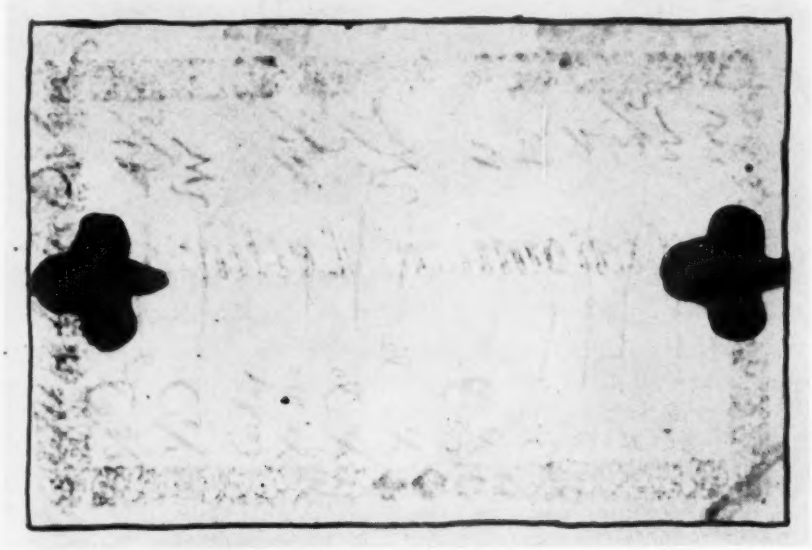


FIG. 4A.—Playing card back of Mr. Brindley's ticket to Hunter's lectures.

who were interested in natural philosophy as well as by those desiring instruction for more practical purposes. As regards their priority in the history of anatomy in this country, there seems to be very reason to accept the belief that

they were the first systematic, advertised, public lectures on the subject known to have been delivered in this country. Thomas Cadwalader, to be sure, had given lectures and demonstrations of dissections in Philadelphia in 1730 (not 1750, as frequently stated) on his return from studying in Europe "for the instruction of the elder Dr. Shippen and some others, who had not been abroad. . . . This probably was the first business of the kind ever done in Pennsylvania." (Wistar.[22]) But how much these lectures and demonstrations approached systematic instruction is a matter still to be determined; certainly there is no known record of their having been publicly advertised.

In the year in which Hunter is supposed to have arrived in this country, the following advertisement was placed in the New York *Weekly Postboy* of

FIG. 5.—The Old Colony House, Newport, in which Hunter gave his lectures.

January 27, 1752, by Thomas Wood, Surgeon: "Whereas Anatomy is allowed on all Hands, to be the Foundation both of PHYSICK and SURGERY, and consequently, without SOME knowledge of it, no person can be duly qualified to practice either: This is therefore to inform the Publick, That a COURSE of OSTEOLOGY and MYOLOGY, is intended to be begun, some Time in February next, in the City of New Brunswick (for which Notice will be given in this Paper, as soon as a proper number have subscribed towards it). In which Course, all the human BONES will be separately examined, and their Connections and Dependencies on each other demonstrated; and all the MUSCLES of a human BODY dissected; the Origin, Insertion, and Use of each plainly shown. This Course is proposed to be finished in the Space of a Month. Thomas Wood, Surgeon.

"Such Gentlemen who are willing to attend this Course, are desired to subscribe their Names as soon as possible, with Mr. Richard Ayscough, Surgeon, at New York or said Thomas Wood, at New Brunswick, paying at the same Time, THREE POUNDS, Proc. and engaging to pay the said Sum of Three Pounds more, when the Course is half finished.

"N. B. If proper Encouragement is given in this Course, he proposes soon after, to go thro' a Course of ANGIOLOGY and NEUROLOGY; and conclude, with performing all the OPERATIONS of SURGERY, on a dead body: The Use of which will appear to every Person, who considers the Necessity of having (at least) SEEN them performed, before he presumes to perform them himself on any living Fellow Creature."

Although this advertisement was subsequently repeated on several occasions in the same journal, I have been unable to find the "notice" that was to follow a sufficient number of subscriptions, so we do not know whether one or both courses were given, or if begun, how long they were continued. Sporadic post-mortem examinations, of course, had been made from the earliest times, usually to ascertain the cause of a suspicious death, but sometimes for purposes of instruction. Thus Eliot, the Apostle to the Indians, as early as 1647, expresses in a letter to Mr. Thomas Shepard, the Cambridge minister, his desire that "our young Students in Physick may bee trained up in making experiments, for we never had but one Anatomy in the Country, which Mr. Giles Firman (Firmin) (now in England) did make and read upon very well." The Apostle's desire seems to have carried weight, as we find the following resolution passed within a month by the General Court of Massachusetts: "We conceive it very necessary y^{t} such as studies physick or chirurgery may have liberty to reade anotomy (sic) and to anotomize once in foure yeares some malefactor in case there be such as the Courte shall alow of." In the same letter to Shepard, Eliot says, "I have shown them (*i.e.* the Indians) the anatomy of man's body." . . . Packard[14] gives the record of a dozen autopsies reported in New England before 1678, and Hartwell quotes from a Maryland Order of Council[13] one of the earliest autopsies performed in this country by legal direction (1670). In 1691, the celebrated autopsy on Governor Slaughter of New York was made, which for a long time was erroneously regarded as the first recorded autopsy in this country. None of these, however, should detract from the distinction of Hunter's achievement.

His opportunities to teach anatomy and surgery must have been sadly interrupted by his military activities. In 1755 he was surgeon in Colonel Harris' regiment in the unsuccessful expedition against Crown Point under the command of Sir William Johnston[3] (see his later letters to Johnston quoted p. 516). "It was in Dr. Hunter's tent the brave Baron Dieskau died"[9] (the French Commander). Hunter also served in the Campaigns of 1756 and 1757[3] and in March, 1758, was elected by the General Assembly physician and surgeon general to the Rhode Island troops. We happen to have the exact date of his departure from Newport (June 29) and can come close to

the date of his arrival at Lake George (July 4).* Although the British under Abercrombie were defeated by the French at Ticonderoga in one of the bloodiest battles on this continent before our Civil War, they were successful in Canada, as elsewhere throughout the world, this campaign leading to the conquest of Canada. Hunter is thought to have served in both Abercrombie's and Amherst's expeditions into Canada.[1] His status as medical officer to the Rhode Island troops appears from the appended vote of the General Assembly.† With the return of the troops after the capture of Quebec and Montreal, Hunter returned to his practice in Newport with marked success.

Ezra Stiles,[19] who bitterly hated Hunter and his Toryism, gives this interesting light on the obstetrics of Newport in 1774: "In Conversation with Mrs. Dennis a principal Midwife of this Town, she told me, that the number of Births in this Town last year was four hundred & thirty, that there would be 440 this year, that the number of actually bearing Women was near nine hundred, and that their usual Term of bearing was from fourteen Months to two years, that is each had a Child once in 14 m° or two years, that of the 900 Women Dr. Hunter had about fifty and might deliver 30 a year; Dr. Haliburton about a dozen Women; all the other Doctors together not so many as a dozen. There are three women Midwives more all which deliver but a few, suppose 20 or 30, I should suppose Mrs. D. delivers 350 or more per annum. I suppose these comprehend Whites & Blacks; of all which there are in Town Nine Thousand Two Hundred souls. . . . Total Souls in Newport last May 7917 Whites, 1292 Blacks and Indians 9209."

Some fragmentary information as to Hunter's methods of practice remains;

* In a letter from the Committee of War of Rhode Island, to Governor Hopkins, dated Newport, June 29, 1758, a letter was enclosed to Colonel Babcock which said, "store ship is arrived, with the arms and tents for the American troops . . . and Dr. Hunter set out this morning for Providence, in his way to Albany. . . ." A letter from Colonel Babcock to Governor Hopkins, Camp Lake George, July 4, 1758, states "Your letter, per Hunter, I received."[16]

† "The General Assembly do vote and resolve, and it is voted & resolved that William Hunter who went & officiated as Physician and surgeon to the troops of this Colony during the last Campaign, shall be paid his wages at and after the rate of ten pounds lawful money, per month, in bills of credit of this Colony, persuant to agreement: that for the ensuing Campaign his pay shall be one hundred & eighty pounds old tenor, shall be procured for him according to his own directions, that in case the said W. H. shd loose, or by any accident be deprived of the medicine chest he shall have liberty & credit with some proper persons, to be pitched upon to that purpose, to supply himself with what shall be found necessary for the remaining part of the Campaign; that Mr. Hunter shall have the same allowance made for him by the Colony for Chirurgical instruments, in this Campaign as he had in the last; that the Colony shall furnish all stores necessary for the accommodation of the sick, who shall be tended and taken care of by a sufficient number of men suitable for nurses, to be selected out of the companies; this assembly not approving that women should be employed for that service; that if any contingent charges should accrue to the Doctor by travelling, transporting or otherwise, it shall be paid him by the Colonies commissary, and lastly, he shall have a marquis or tent provided for him." Bills of the old tenor were sealed at £5.10.0 to the dollar (Rhode Island Republican[2]).

as for instance, a prescription "For Mrs. Arnold ℞ Tincture: perm: Elix^{r}—Vitriol: Sign the Tincture half a tablespoonfull of which to be taken in a cup of Balm Tea morning, noon, and night every day Ap^{l} 24, 1771." The following items from his ledger give a glimpse at his daily methods, drugs and prices. Errors of spelling and punctuation, though they somewhat confuse the meaning, have been left as in the original. "Dos Ex. Ipecac No.; Bol. No. Ex. Vitre Antim; a child—Dos. ex Rhei.; Dos. Ex. Sal. Glaub.; Mist. Anod.; Bol. ex. Rhei.; Pills; Plasters; a. operation hard open abscess in her throat 3/; b. to directing a proper complex bandage and tapping you 2/8/0; Ph. Tinct.; Bol. Capini; The Strong Mixture Empl. Epis.; Jallay's Solut.; Mix^{r}. Hydragog.; Bol. Ex. Opium No. VI 4/; Mix^{r}. purg. u. a.; Decoc. ex. F. Senna; Pil. Ex. G. Gambage—case of dropsy; Child—emetic; Ph. Tinct. c. Peru. & Rhei. 3/6; Ph. of Balsam; Box of Pectoral pills; A blister inter scapula 2/0/0; Child. Dos. ex. Calom. No.; Nov. 6, 1763—To delivering your wife of a Dhgt—8 dollars or 2/8/0, The above made a present of; Nov. 29, 1765—To delivering ditto in dangerous labour of a son—6/0/0 (N. B. No further charges follow so that in each case the charge is apparently until the wife is well); Dec. 20, 1767—Delivered of a daughter dangerous labour 6/0/0; Mr. Nichols—Comptroler—yr. negro boy salivated 90/0 = 4/10/0, yr. negro woman visited /3—3; Us. cured of the venereal disease /60 = 3/0/0; Sept. 1768 To curing you and yr. wife of the venereal disease /120—6/0/0; Aug. 12, 1769 Cured a second time of ditto /120—6/0/0; May 21st, 1764 Cabel Arnold Carpenter near Parson Browns—Daughter a box pills 2/6d—, a pt. of Tinct^{r}. 1/3d—, V. twice 6/—0/9/9; 23rd, Visited 3/, 25th visited 3/, 27th visited 3/, 29th visited 3/—0/12/0; 30th R. pil & Tinct. 3/9d, 31st visited 3/, July 9th a pt. of Tinct. 4/6d—0/11/3; July 9 Visited 3/, 12th R Tinct. 4/6d, and visited 3/, 17th ℞. Tinct. 4/6d—0/15/0—total £2/8/0; Jany. 21, 1771, Visited in the night 9/, Bol. purg. 1/6, visited 3/, 22nd visited 3/, 0/16/6; 23d. Al: Decoct purg 7/6 visited 3/—; Dec. 21, 1773 Given in—£7-4-0; February 1768 Given in; April 11th Then received the above in full Wm. Hunter; 1768 Mr. Allborough, a fisherman oposite (sic) Capt. Carrs on the point in Kindal Nichols house; July 2d. To delivering your Wife in dangerous Labour 120/—£6.; Lawf. money; July 30, 1771 Fanny Demmerson an Indian at .... Cured of L.V. 60/ Hot Chases; Aug. 29, 1771, Hannah Church, a mulatto at Finsons Cured of L. Vencr. 60/. Jan. 1772 paid in part one guinea."

In 1765 and 1768, we find that Mr. George Wright incurred the following charges, amounting to £4.6.3 "Lawful money." Was he not in need of medical attention in the intervening years or was a colleague having his innings?

	Sh.	D.
June 5th Mrs. Wright a box Ointment 2/6. & a Box pills 6/3d.....	8″	9″
– and Visited 3/– 6th Visited 3/– 7th Visited 3/–	9″	
10 Visited 3/– 11th the Ointment Repeated 2/6	5″	6″
14 the pills Repeated 6/3– and twenty powders 5/– .....11″		9″
and Visited 3/– 22d the pills as before 6/3	9″	3″
22^{d} and powders; again 5/– and Visited 3/– July 4th visited 3/.....11″		–

		Sh.	D.
Septem[r] 15.	a Box pills 9/6 and more Ointment 2/6	12″	–
1768	and Visited twice 6/	6″	
August 2[d]	Visited Mr. Wright 3/– 3[d] Drefsed his hand 3/	6″	
	3[d] and spread plaister /6 & Ointment 1/ 4th Drugs Dit. 3/	4″	6″
	6[th] Drugs dit 3/	3″	

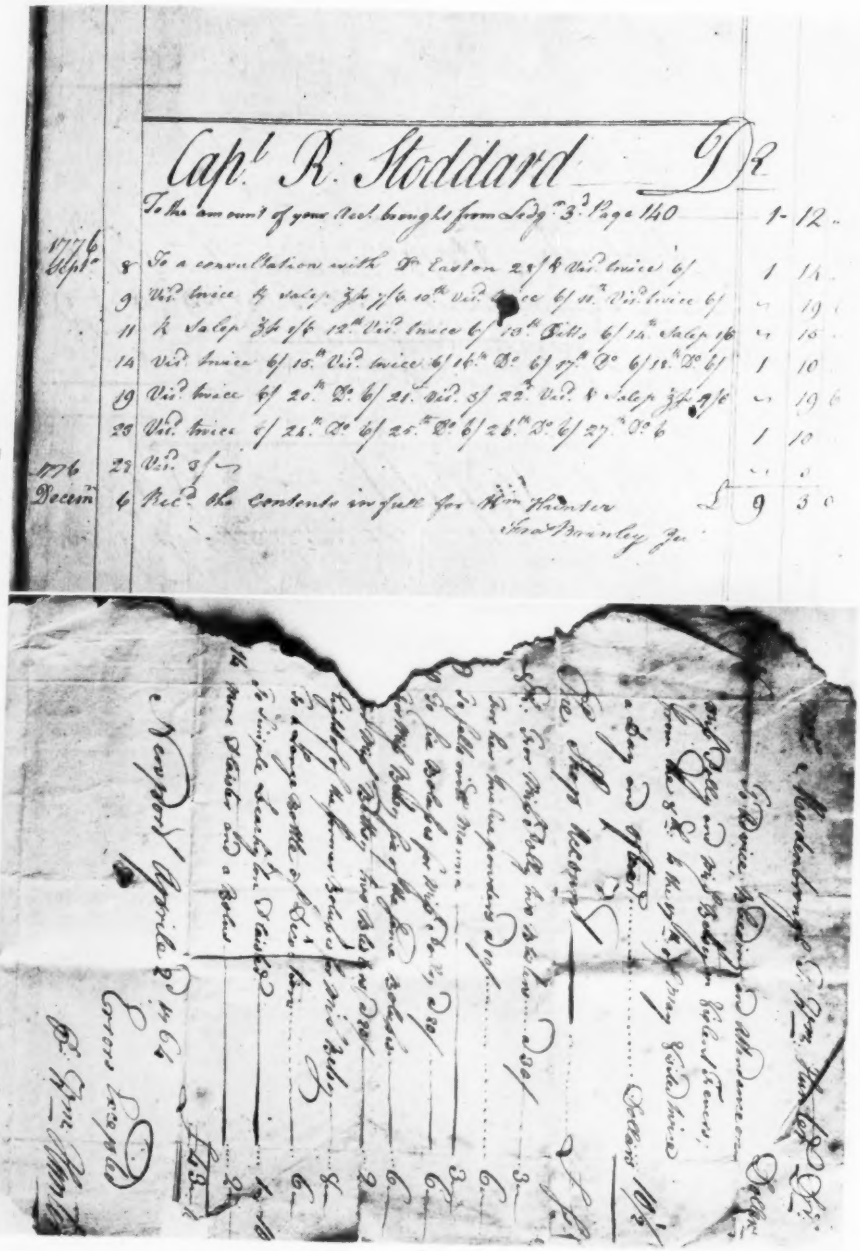
The illustrations on the next page will give further light on the kind of practice that he pursued (Fig. 6).

Captain Edward Wanton continued as his patient, at least into 1770, as is proved by Hunter's letter to him about his Gout (Fig. 7). This does little more than reflect the views on gout current at this period. The two following letters (in the possession of the Pennsylvania Historical Society) may be taken as characteristic of Hunter's courtesy, urbanity and good common sense in his attitude toward health and disease:

"The Honb'le. Sir William Johnston (sic) Baronet at New London. Newport May 10, 1768. Sir: Nothing but Mrs. Hunter's being in the Straw and not well enough to be left shou'd have prevented me at this time from the pleasure of waiting upon you at New London. As you are come this way for the benefit of the Sea-Air let me persuade you to pass a few days with us on this pleasant Island surrounded by the Ocean. Here you will enjoy more of the Sea-Air than is to be found on any other spot on the Continent. The Vapours or fogs that infest us at this season of the year and that may be deemed unhealthy to the Inhabitants I will venture to say will prove salutary to you that have lived so many years at so great a distance from the Ocean. Dr. Moffatt who is capable of giving you the best advice I dare say will confirm this. I shall do every thing in my power to make the place agreeable to you and altho there are many here that can and will entertain you with more elegance and Splendour than I can yet I am sure there are none that will give you a more hearty welcome or be more pleased to see you than Sir Your Most Obedient Humble Servant Wm. Hunter."

"To the Hon. Sir W[m]. Johnson. Newport, March 15, 1773. Sir: The account our worthy friend Mr. Chew gives of the state of your health affords me great pleasure. I hope you will make it your study to preserve it, by varying your scenes of life, and not confine yourself to the Inland part of the country, which cannot long agree with a constitution, that has been used to the more salutary sea-air. You will find it necessary, and I hope you will not neglect visiting, the Sea-Coast once in three or four years. You are sensible how much easier it is to prevent sickness, than it is to restore health, therefore while you are able, come down and spend the two hot summer months on this Island, and in the Fall you shall return with a sufficient store of Health for years to come. There can be no doubt that, in general, temperance is the foundation of health, yet to indulge now and then has always been allowed; but if you will honour me so much as to become my guest, depend upon it, you shall be allowed to do as you please, and it shall be our study to make everything agreeable to you. Mrs. Hunter who is the daughter of Wm. (?)

FIG. 6.—Some bills to Hunter's patients.



Capt. R. Stoddard Dr

To the amount of your Acct brought from Ledg.r 3.d Page 140 — 1 - 12 -

1776 Sept.r 8 To a consultation with Dr Easton 2 3/4 Vis.ts twice 6/ — 1 14 -
9 Vis.t twice & Julap 3/6 10.th Vis.t twice 6/ 11.th Vis.t twice 6/ — 19 -
11 & Julap 3/6 12.th Vis.t twice 6/ 13.th Pills 6/ 14.th Julap 16 — 18 -
14 Vis.t twice 6/ 15.th Vis.t twice 6/ 16.th Do 6/ 17.th Do 6/ 18.th Do 6/ — 1 10 -
19 Vis.t twice 6/ 20.th Do 6/ 21.st Vis.t 3/ 22.d Vis.t & Julap 3/6 9/6 — 19 6
23 Vis.t twice 6/ 24.th Do 6/ 25.th Do 6/ 26.th Do 6/ 27.th Do 6 — 1 10 -
1776 29 Vis.t 3/ — - 3 -
Decem.r 6 Rec.d the Contents in full for Wm Hunter — £ 9 3 0
Tho.s Bromley Jun.r

Fig. 6.—Some bills to Hunter's patients.

Malbone, your former acquaintance and particular friend of your Uncle Sir Peter Warren, wou'd be happy in paying attention to you, and I am sure, the Jaunt, wou'd contribute to the Establishing of your health, which all your

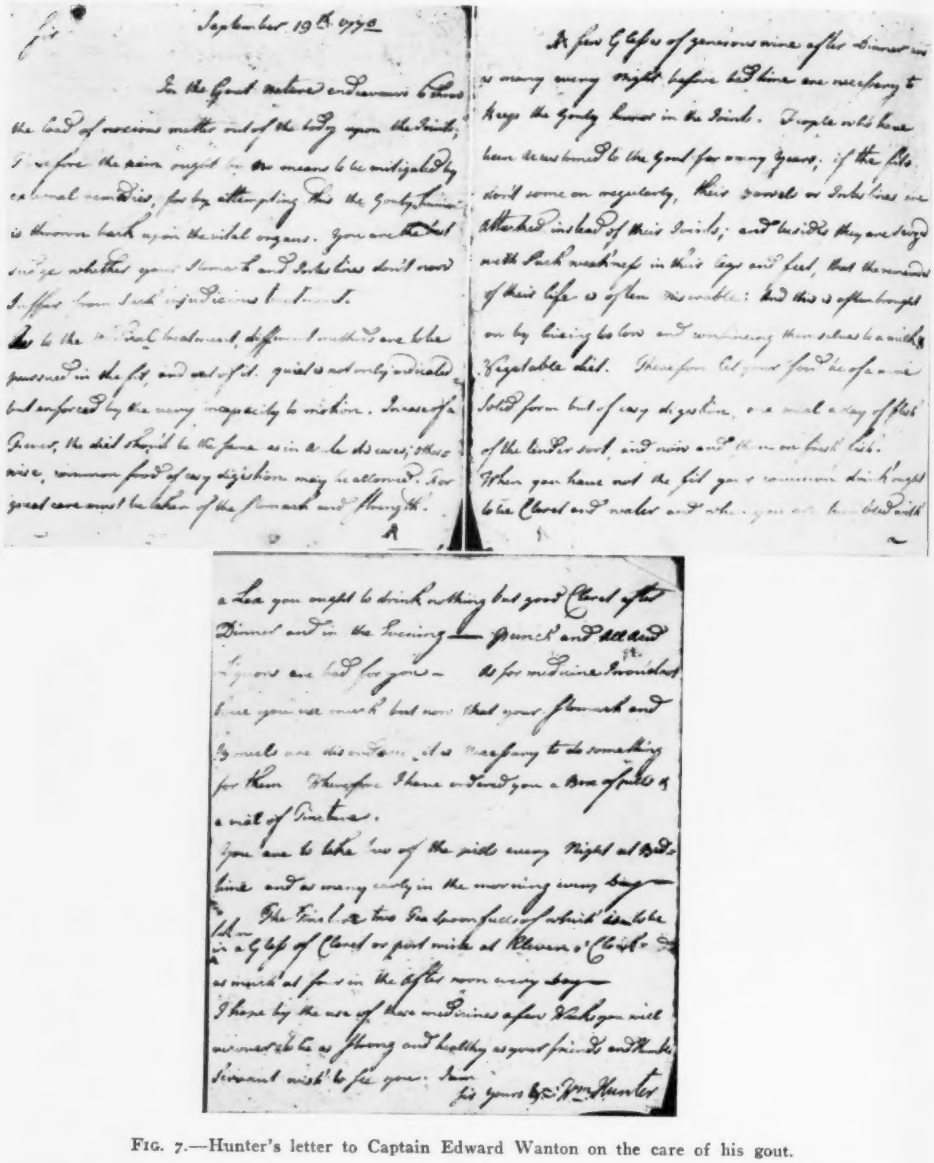


Fig. 7.—Hunter's letter to Captain Edward Wanton on the care of his gout.

friends are so desirous to see confirmed.—I am Sir Your very Humble Servant Wm. Hunter."

Hunter imported his own drugs, mostly from a Mr. Witherly and Messrs. Corbyn and Co., Druggists, Holborn, and had an apothecary to put them up

and sell them. The successors of this apothecary remained in the Hunter house until comparatively recent times. When the house was sold a few decades ago, a number of old glass jars and delft gallipots were found in the attic, of which photographs are reproduced (Figs. 9 and 10). Thacher says that "he was a most eminently successful practitioner, as well as an operator in surgery; he appeared at that day to be bold and rash, but the truth was, he brought with him from Europe a more exact knowledge of anatomy, and greater chirurgical skill grounded on that knowledge, than existed in the colonies at that period."

For the first ten years of his life at Newport, Hunter lived in the "old

FIG. 8.—Hunter's Apothecary Shop, Thames and Mary Streets, Newport.

Rodman House," originally on the corner of Ann (now Touro) and Thames Streets (Newport's principal thoroughfare), but now—like so many of the old Newport houses—standing on Bridge Street, second house from Washington Street (Fig. 11). Its fine proportions, numerous windows, hip roof and clapboarded sides tell their own story in spite of the bad times that it now seems to be experiencing. This house was occupied by Thomas Rodman (1647–1727) who came from the Barbadoes in 1680. After his death his son Thomas lived there, then Hunter, then Dr. John Haliburton (Dr. H. B. Jacobs' note). Hunter later lived on the Corner of Mary and Thames Streets, in a house that has also been moved to Bridge Street to make way for a candy

store and is said to be still in existence (Fig. 12). We show another "Hunter House" of the same style on Washington Street (reproduced from a newspaper clipping) (Fig. 13).

On September 13, 1761,[9] in old Trinity Church, Hunter married Deborah (born November 23, 1744, died abroad), the youngest daughter of Godfrey Malbone (1724–1785), who was educated at Oxford and was "one of the most

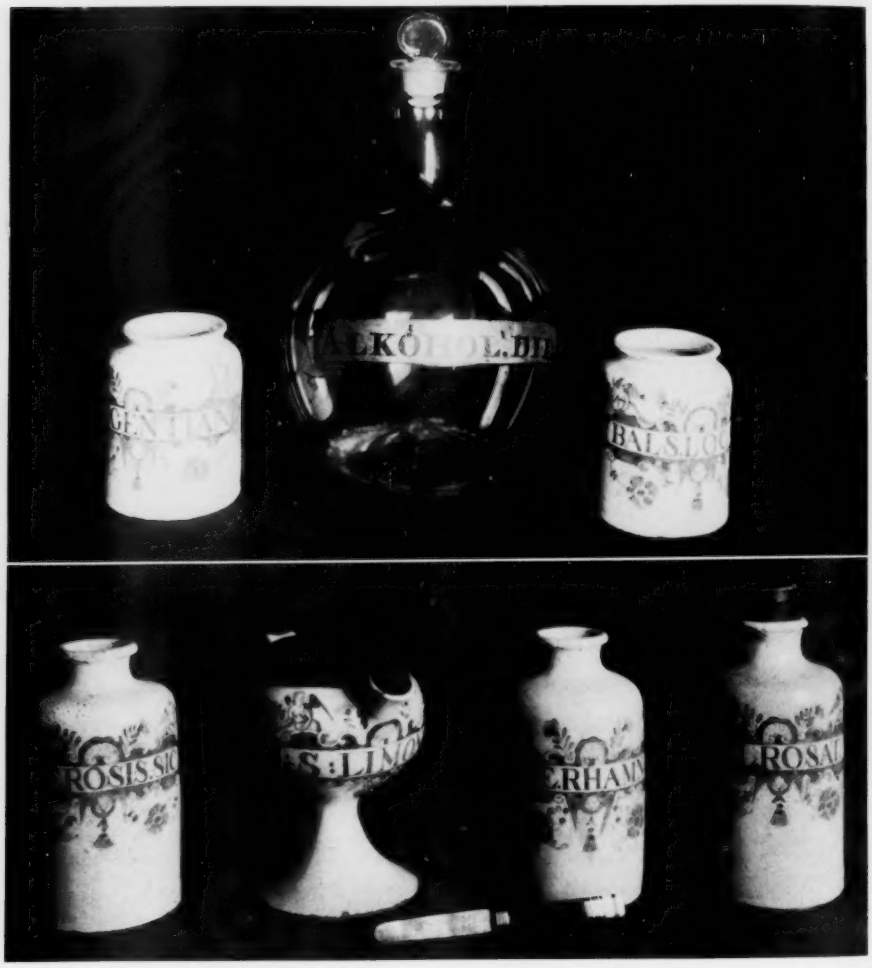


FIG. 9.—A glass flask from Hunter's pharmacy (belonging to Anna M. Hunter) and two "Gallipots" (called Galley Pots in the inventory) (heirs of Kate Hunter Dunn).
FIG. 10.—More of Hunter's Gallipots and a Spatula with agate handle (Newport Historical Society).

opulent merchants and land proprietors of the country" (Thacher). A few months later Hunter became one of the "undertakers" to pay for an enlargement to the church, of which his father-in-law was a vestryman, "for which they are to have the pews, subject to a tax for defraying the expenses of the church."[9] Hunter's pew was No. 13 (Fig. 14). The original Malbone house was destroyed by fire. While it was burning Colonel Malbone, the owner, is

said to have remarked: "Though we lose our home, there is no reason to lose our dinner." The Hunters had seven children, of whom three, William, Katharine and Godfrey Malbone, died in infancy. Three daughters died abroad, Elizabeth (1762–1859), Anne (1766–1859), wife of John Falcounet (Falconer), and another Katharine (1773–1860) wife of the Count de Cardignan. Another William, the youngest child (1774–1849), was "a lawyer of very great classical and scholastic attainments."[1] After studying law at the Inner Temple, he gained a prominent position at the Rhode Island bar, was

FIG. 11.—The Rodman House, Newport.

Senator from Rhode Island, 1811 to 1821, and long Minister to Brazil. He has numerous grandchildren and great-grandchildren living today.

As seen by his portrait, the elder Hunter was a handsome, well-dressed gentleman. This painting (Fig. 1)—by Cosmo Alexander in 1769, owned by W. R. Hunter, of Middletown, R. I.—shows the white bag wig and stock of the period with the ruff of the waistcoat appearing from under the black coat. It is marked on the back "Dr. William Hunter, born in Edinburgh, Scotland, died at Newport Jan. 30, 1777." Thacher says of him: "He is reported to have been somewhat too handsome for a man; his manners were

courtly and amiable, his opinions liberal and his literary relaxations were the classics."

Ezra Stiles, the Congregationalist minister, President of Yale, who could not forgive Hunter's antagonism to the cause of liberty, gives us the following brilliant, if one-sided, bit of portraiture (journal of February 9, 1777).[19] "Heard of Dr. Hunters death in Newport. He was Scotch Physician—spent about two years in attending the medical Lecture in University of Edinburg—then came over to America 1754 circa, with nothing. Settled at Newport, where he got an Estate, turned Chhman (Churchman, i.e. Church of England), became as haughty as a Scotch Laird, high in ministerial and parliamy

FIG. 12.—Hunter's House on Thames and Mary Streets, Newport.

Measures, an inveterate Enemy to American Liberty—dressed well, was much of the Gentleman, lived high & luxuriously—could approve nothing but what was European, despised American Literature & Colleges—of polite Morals. Of natural good Sense & a taste for the belles Lettres—but not a man of any great Reading in any Branch of Learning, even that of his own Profession. He tho't he bro't knowledge eno' with him out of Scotland, at aet. 21, for a physician in America. He determined his Mode of Religion upon secular & political Motives, such as would have joyned him to a Mosque in Turkey, the House of Rimon at Damascus, or St. Peter's at Rome. Had he taken time for inquiry into his own real principles, he would probably have found them the same as David Humes or some other Scotch Deist—but he was not disposed for such a self-examination; and had he known himself a

Deist, he would yet have been a Scotch Chhman in New Engld, from his Hatred of New Engld Presbyterians."

Hunter is said to have been [1, 4, 17] the first patron of Gilbert Stuart, the celebrated painter. While visiting the mainland to see patients, Hunter was struck by the drawings in chalk on a certain barn door. Seeing other meritorious drawings upon later visits, he investigated the matter and found that the boy, Gilbert Stuart, had made them. Hunter then gave him money to take drawing lessons. After a time the boy visited him in Newport and Dr. Hunter asked if he was ready to begin painting. The boy replied that he thought he was; whereupon the Doctor said: "Well, paint my dog." The original of this picture is now to be seen in Newport in the house of Mrs. William E.

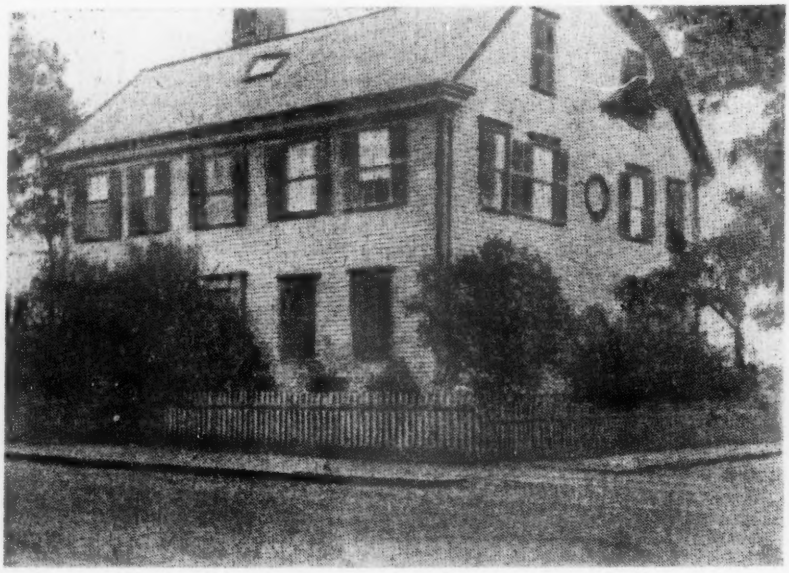


FIG. 13.—Hunter's House on Washington Street, Newport.

Glyn, a great-great-granddaughter of Doctor Hunter. Stuart, who was born at Middletown, R. I., in 1755, even at thirteen had begun to show his talent, and two of his portraits (of himself and Dr. Benjamin Waterhouse) painted before 1770, the year in which he first had instruction in art, hang in the well-known Redwood Library in Newport. (Dr. H. B. Jacobs.)

Like many of the Scottish emigrants to the colonies, Hunter remained a loyalist and was from the start a frank supporter of the home country's authority. He is known[11] to have been a subscriber in 1767 to the anti-colonial Boston *Chronicle*, and as the clouds gathered preceding the Revolution, he did not hesitate to denounce "the dom'd Rebels."[1, 19] On Christmas Day, 1775,[10, 19] Hunter was among eight Tories brought before General Lee to swear renunciation of Tory principles, fidelity to the American cause and readiness to take arms in its defence when called upon by the Continental Congress. The three who did not take the oath are listed and Hunter's name is not among

them; nevertheless, he as a physician, and Mr. Bisset, as a clergyman, were exempted from the statement about taking arms.[10, 17] On July 18, 1776, however, the General Assembly resolved that Hunter, who with several others had refused to subscribe to the declaration it had prescribed, be removed by the Sheriff to Smithfield, R. I.[16] The declaration to which Doctor Hunter refused to subscribe read as follows: "Declaration or Test, to be made by suspected persons in the Colony, relative to the War with Great Britain: 'I, the subscriber, do solemnly and sincerely declare, that I believe the war, resistance, and opposition, in which the United American Colonies are now engaged, against the fleets and armies of Great Britain, is on the part of the said colonies

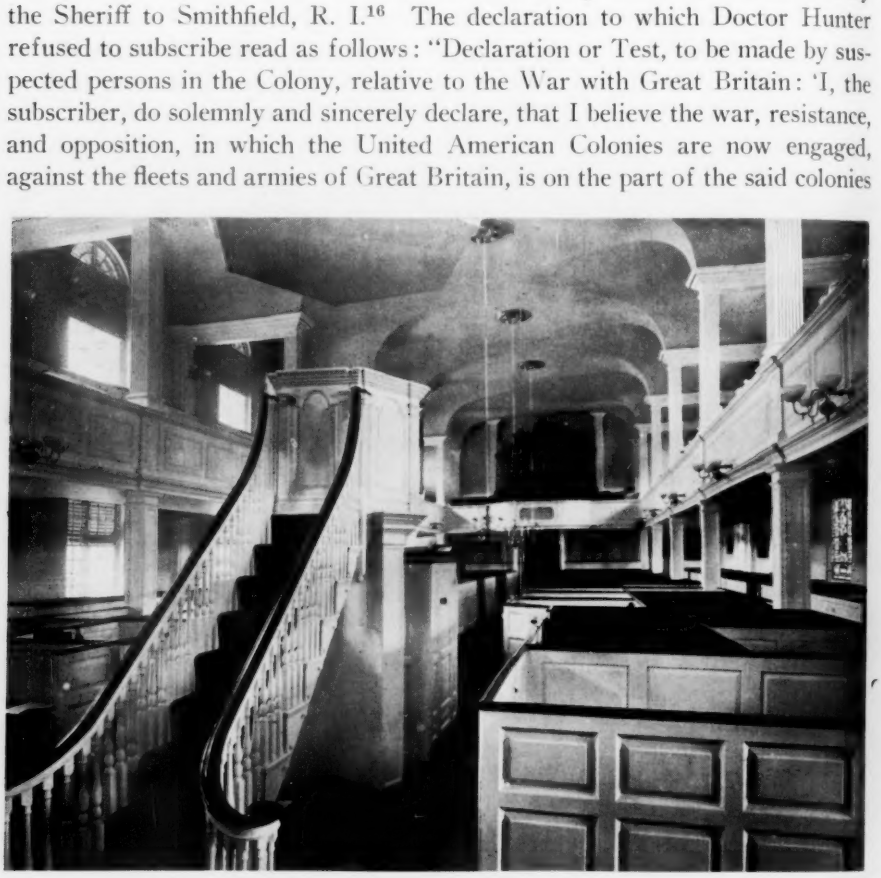


FIG. 14.—Interior of Trinity Church, Newport, with Hunter's Pew.

just and necessary; and that I will not, directly nor indirectly, afford assistance of any sort or kind, whatever, to the said fleets and armies, during the continuance of the present war; but that I will heartily assist in the defence of the United Colonies.'" In August, however, he was permitted to return to Newport on account of the dangerous illness of one of his children, and three of the state magistrates were "appointed to direct when the said Doctor Hunter shall be sent back to Smithfield."

When the British took Newport, December 8, 1776, Hunter's ease was assured. His name occurs in Stiles' list of those in the city at that time[19]—one of about a dozen to be marked with four stars, *i.e.*, the most extreme of Tories. He took great pleasure and satisfaction in the local predominance of his side, but his triumph was short-lived. He contracted a "putrid fever,"

while in attendance at the Army Hospital (according to one account),[6] or while attending sailors—prisoner of war on a man of war in the harbor (according to another).[5] After a short illness, he died on January 30, 1777. In the February 7th number of the *Newport Gazette*, a paper sponsored by the British while in occupation, the following obituary was published: "Last Friday night departed this life Dr. Wm. Hunter in whom concentrated all those virtues wh. adorn the patriot, form the husband and compose the parent. The town has sustained a loss which can not be repaired. His worthy consort is deprived of the most engaging of husbands and his children the best, the fondest of parents. The patience with which he bore the many & un-

FIG. 15.—Hunter's Tombstone in Trinity Churchyard.

provoked insults of his countrymen in full confidence that relief would soon arrive deserves every encomium and perhaps the goodness of his disposition is not in any instance more conspicuous than in forbearing to retaliate the injuries of many whom the restoration of the authority of his sovereign had placed in his power." He was buried in Trinity churchyard (Fig. 15) near those of his children who had gone before. His tombstone reads: "In memory of Doctor William Hunter who departed this life on the 30th of January 1777 in the 47th year of his age." His widow and three beautiful daughters were highly regarded. "Among the maidens of Newport who were adored by the French officers were the Misses Hunter. The gay followers of Rochambeau sang their praises and traced their names upon the windows of their quarters." (Mason.[9]) When the eldest daughter, Eliza, was threatened with

blindness, Mrs. Hunter sought help for her in Europe, taking the others with her and none ever returned. Contemporary accounts, as well as two miniatures still in the family possession, proclaim their charms. A Mr. Chipman writes in his journal: "We have heard much of Miss Hunter of R. I. who was at Dr. Lloyd's; we were prepared to expect something supernatural. We called to see her; our expectations were exceeded by the interview. She is, without exception, the most beautiful, accomplished, and elegant person (with a mind, if possible, as we were informed by her friends, superior) that I ever beheld."

His will was not probated for almost three years (Newport Town Council, December 30, 1779).[12] It reads: "In The Name of God, Amen, I William Hunter, of Newp^{t} in y^{e} County of Newp^{t} in y^{e} Colony of Rhode Island, Physician, being sick & Weak, but of a disposing mind & memory, do hereby make this my last Will & Testament, & dispose of such Estate, as I am Blefsed withal in the following manner to Wit, Imprimis, I Give, Bequeath, & devise, to my Dear Wife, the Income & Profits of One Third part of my Real Estate, during her Life, as also one third part of my Personal Estate, Item, all the Remainder of my Estate both Real & Personal I order to be Divided by my Ex^{rs} into five Equal parts, Two parts of which I Give, devise, & Bequeath to my Son William, His Heirs & Assigns forever, & the other Three parts, I Give, devise, & Bequeath to my three Daughters, Elizabeth, Anne, & Catharine, Share & Share alike to them, their Heirs, & Assigns forever, Item, my mind & Will is, & I order that my Wife shall have & receive y^{e} Issue & Profits of my Real Estate, till my Youngest Child Comes of Age, & that my Daughters receive their shares of my Personal Estate when they Respectively arrive at y^{e} age of Twenty one Years, And, Lastly I appoint my s^{d} wife & my Two Friends, Francis Brindley & Simon Pease Ex^{rs} of this my Last Will, dated at Newport this thirtieth day of January A D 1777 Wm. Hunter—Seal Sealed & Acknowledged as his last Will in presence of us Francis Brindley Jun^{r} Penelope Bisset A Johnston Newpo^{t} The aforegoing is a true Coppy of y^{e} Original Will of William Hunter Recorded & Compared, by Me this 15th day of decb^{r} A D 1780 Peleg Barker Jun^{r} Council."

The inventory of his personal estate, made a week later, throws an interesting light on the materia medica of the day, but is too long to be included here. The huge number—according to present viewpoints—of 273 drugs is listed, in amounts varying from one drachm of cinnamon, valued at 15s., to thirty-one pounds of ammonia. Not a few old friends are encountered, such as aloes, arsenic, paregoric, hyocyamus, sulphur, cinnamon, ether, opium, santonin, jalap, lunar caustic, tartar emetic, castor, antimony, cantharides, James' powders. But most have long since departed from our pharmacies, many are unrecognizable; some are as startling as "Sang. Draconis," of which six ounces were valued at one shilling three halfpennies. Among the furniture is listed "One Neagro (*sic*) Man Named Mark" £22.10 (exactly the same valuation as for a roan horse two lines later). Another Negro, named Quarts, was worth considerably less (£13.10) than the chaise (£18). In the

Notes of Hand, we find 129 individuals listed for amounts varying from six shillings to 2,500 pounds and totalling £7,860, 6s. and 6 pence.

Why should this man be given a distinguished position in early American medicine? Certainly not on account of his famous namesake, whether or not the relationship could be proved. The manuscript of his lectures, if it could be found, would of course afford a much more valid basis for judging his medical attainments than the scanty statements given here. According to Thacher, he corresponded with Cullen and "his own illustrious kinsmen," but it has not been possible to uncover this evidence. At least, no letters from the Hunter brothers to their ancestor are known of by his descendants today. It might fairly be said that, possessed of unusual charm of personality and culture and of more than the average natural intelligence, fortunate in being trained in one of the best medical schools in the world, Hunter came to a new country where such a combination was rare. Seized with the happy idea of offering instruction to his fellows and doubtless the best qualified to give it at a time when need for such systematic study was beginning to be realized through the colonies, he unquestionably deserves the fame for having been the first known in this country to have given a publicly announced, successful course of lectures on anatomy and surgery. The importance of such an achievement need hardly be further emphasized. His military activities and successful professional career bear further witness to his worth and ability. Nor should his political attitude during the Revolution be regarded as other than the natural response of one of his position—an attitude similar to that of many of the leading citizens of New York, Pennsylvania and New England, well understood by most of their class and easily forgotten in favor of those who threw in their lot with the new country after the war was over. What the country lost by his early, untimely death can only be conjectured. From what we know of him, he doubtless would have agreed with Alfred Stillé: "Only two things are essential, to live uprightly and to be wisely industrious."[20]

I am grateful to Mr. Arnold Borden, Research Librarian of the University of Pennsylvania Library, and especially to Dr. Henry Barton Jacobs, for the great help that they have given me in collecting material for this study.

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AMNIOTIC FLUID

A CLINICAL STUDY

By James T. Lacey, M.D.

of Southbridge, Mass.

In 1930, the author published the results of an experimental study on the prevention of "Peritoneal Adhesions by the Use of Amniotic Fluid."[1]

About this same period Kubota,[2] Johnson,[3] Warren,[4] and Trusler[5] reported experimental and clinical studies on peritoneal adhesions. The last three also used amniotic fluid.

Since 1931, there have been few papers published on the subject. In 1932, Kimpton[6] made a clinical report of a single case in which the use of amniotic fluid appeared to prevent peritoneal adhesions. One cannot but wonder if Kimpton's skillful surgical technic was not mainly responsible for his good result.

Coincident with the author's experimental study, the Eli Lilly Research Laboratory produced a concentrate of amniotic fluid of Amfetin, and furnished a generous supply for the author's experimental work. Briefly, this work consisted of three separate studies of the amniotic fluid concentrate.

(1) The intestines of rats were traumatized. In half of the series amniotic fluid was introduced into the peritoneal cavity before closure and the other half used as controls. At autopsy there was no difference in the density of the adhesions between the control and those treated with amniotic fluid.

(2) A series of intestinal anastomoses was performed on dogs, using amniotic fluid in half of this series. The amniotic fluid did not influence detrimentally the suture lines, nor prevent protective adhesions, but the adhesions were dense in all cases but one of the entire series, and this one was in an animal treated with amniotic fluid.

(3) Chemical peritonitis was produced in another series of rats and in this group those treated with amniotic fluid showed an abundance of leucocytes in the smears from the peritoneal exudate, while smears from the untreated animals showed a predominance of red blood-cells. The conclusions drawn from this work were as follows:

(1) The amniotic fluid is harmless when injected into the peritoneal cavity.

(2) It seems to stimulate the peritoneum to a more powerful defense reaction.

(3) It cannot be depended upon to prevent adhesions.

Within the last three years Eli Lilly & Company have improved their amniotic fluid concentrate and have put it on the market as Amfetin. It has been suggested that large quantities of Amfetin be left in the peritoneal cavity of human beings after abdominal operations.

Forty-two consecutive cases comprised the series for study. Seven of these were drainage cases. Amfetin 50–150 cubic centimetres was used alternately with corresponding amounts of normal saline. The cases in which saline was used constituted the control series and no discrimination was made between the two solutions used in their alternation for this ordinary run of abdominal cases.

Observations were made post-operatively on the leucocyte count, nausea, vomiting, distention, pain, and return of peristalsis.

The mode of introduction of the solution into the peritoneal cavity de-

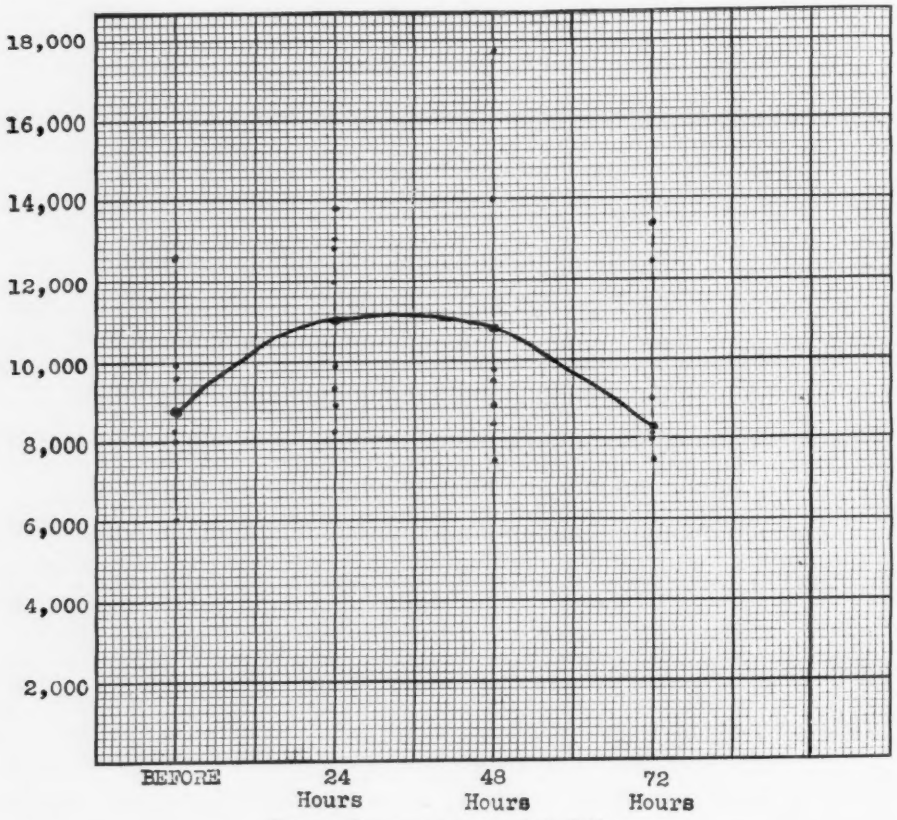

FIG. 1.—Non-acute cases amniotic fluid.

serves mention because of the difficulties encountered. Generally a catheter with a funnel attached was introduced into the peritoneum just before the final peritoneal suture was tied. In this manner, after the fluid had run in, the peritoneal suture could be tied as the catheter was withdrawn, thereby preventing the escape of fluid. In some cases under spinal anæsthesia, the peritoneum could be lifted up and the fluid poured from a graduate. In drainage cases, however, it was difficult to run all the fluid in and to keep it in. It was also hard to estimate how much fluid was lost.

There was only one death in the series. This was a case of perforated appendicitis with general peritonitis of forty-eight hours' duration. One

hundred cubic centimetres of Amfetin were introduced in this case after appendectomy with drainage. Approximately half of the fluid escaped around the drains. At operation the intestines seen were typically red and covered with a plastic exudate.

The patient died forty hours after operation and post-mortem examination showed the peritonitis was quite well localized to the right lower quadrant and around the drains. The patient undoubtedly died from toxæmia rather than from spreading of the peritonitis.

One case in the series was reoperated on. The original operation was

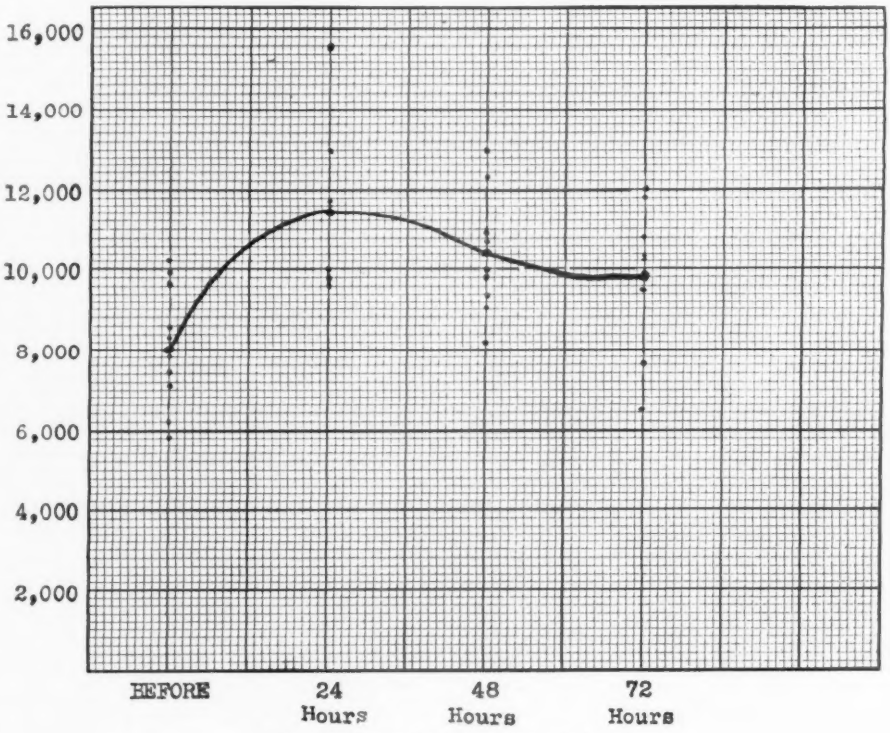

FIG. 2.—Non-acute cases saline solution.

for acute perforated appendicitis with peritonitis. One hundred cubic centimetres of saline were introduced into the peritoneal cavity on closure. Just two months later the patient was seen, and a pelvic mass discovered. The old incision was reopened on the diagnosis of residual pelvic abscess. The mass was found to be a large tubo-ovarian abscess on the right side of the pelvis. There were many quite dense adhesions and considerable inflammatory reaction about the abscess.

One year and two months later the patient was again operated on for incisional hernia, and, as might be expected, there were many dense adhesions about the scar of the two previous incisions. The pelvis and right lower quadrant were, however, relatively free of adhesions.

The above two cases are the only check on the efficiency of the Amfetin in

preventing adhesions which I can report. A comparison is offered, but no conclusions can be drawn.

In discussing the other properties of the agent; namely, its power to stimulate a defense reaction, much has been written about the reaction of the peritoneum to trauma, particularly to bacterial trauma.

It was the author's privilege to attend a symposium on this subject at the

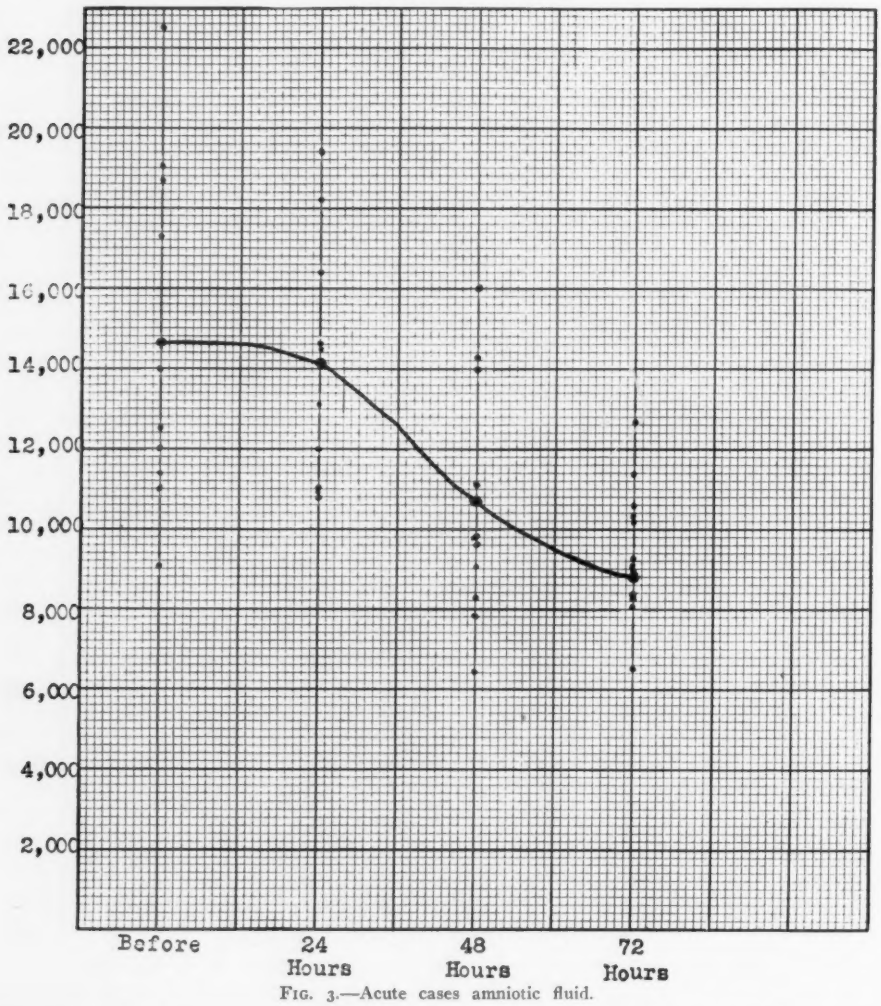

FIG. 3.—Acute cases amniotic fluid.

1934 Clinical Congress of Surgeons in Boston. Johnson[3] and his associates have continued their work and presented results which as yet have not been published. They found that after injection of Amfetin into the peritoneal cavity, sections of the peritoneum taken at intervals showed first the œdema of the subserosa and the migration of leucocytes into the subserosa and later to the serosa. This was closely followed by the appearance of many histocytes. Johnson showed sections forty to forty-eight hours after injection

of the Amfetin, with an exudate made up of leucocytes and débris being lifted off the serosa, leaving behind a smooth surface, the serosa literally flooded with histocytes. If it is true that the influx of histocytes into the peritoneal serosa brings about repair following peritoneal trauma, then Johnson has gone a long way toward proving the potency of Amfetin in combating peritonitis. It should be remembered, however, that in the rabbit normal saline produces a similar reaction.

An effort was made in the series of patients studied by me to estimate clinically the reaction of the peritoneum to its trauma. The return of peristalsis was noted in numbers of hours post-operatively. If the time seems long it must be remembered that there are several cases of peritonitis in the series. The average time of return of peristalsis in the controls was sixteen hours and in the cases treated with Amfetin the average time was 16.66 hours.

The results on the occurrence of post-operative abdominal pain is noted in the following table:

TABLE I

	Amfetin Per Cent.	Saline Per Cent.
Slight	15.00	15.78
Moderate	35.00	52.63
Severe	50.00	31.57

Table II represents the degree of post-operative abdominal distention.

TABLE II

	Amfetin Per Cent.	Saline Per Cent.
None	64.21	70.00
Slight	20.05	10.00
Moderate	20.05	15.00
Severe	5.00	5.00

In the two foregoing tables the subdivision of cases according to anæsthetic, whether general or spinal, made no appreciable difference from the percentages recorded.

Observations on post-operative nausea and vomiting are tabulated with a subdivision for the anæsthetic used. The average time in hours for the cessation of nausea and vomiting is recorded in Table III.

TABLE III

Amfetin..... 11.84 hrs.		Saline..... 18.14 hrs.	
Spinal	General	Spinal	General
1.25 hrs.	14.66 hrs.	19.14 hrs.	17.64 hrs.

Systematic leucocyte counts were made just before operation and twenty-four, forty-eight, and seventy-two hours post-operatively on each patient. Figures I and II show all the non-acute cases. Fig. I the cases treated with Amfetin and Fig. II the controls. Figs. III and IV show correspondingly

the acute cases. The arithmetical averages are plotted. In comparing the non-acute cases, it will be noted that the rise in leucocyte count is most marked in the first twenty-four hours, and that the rise is higher in the controls. After the first twenty-four hours there is a fall in leucocyte count much more rapid and greater in the cases treated with Amfetin, the average white-cell count being lower at the end of seventy-two hours than before operation. In the controls, the white-cell count is somewhat sustained. The

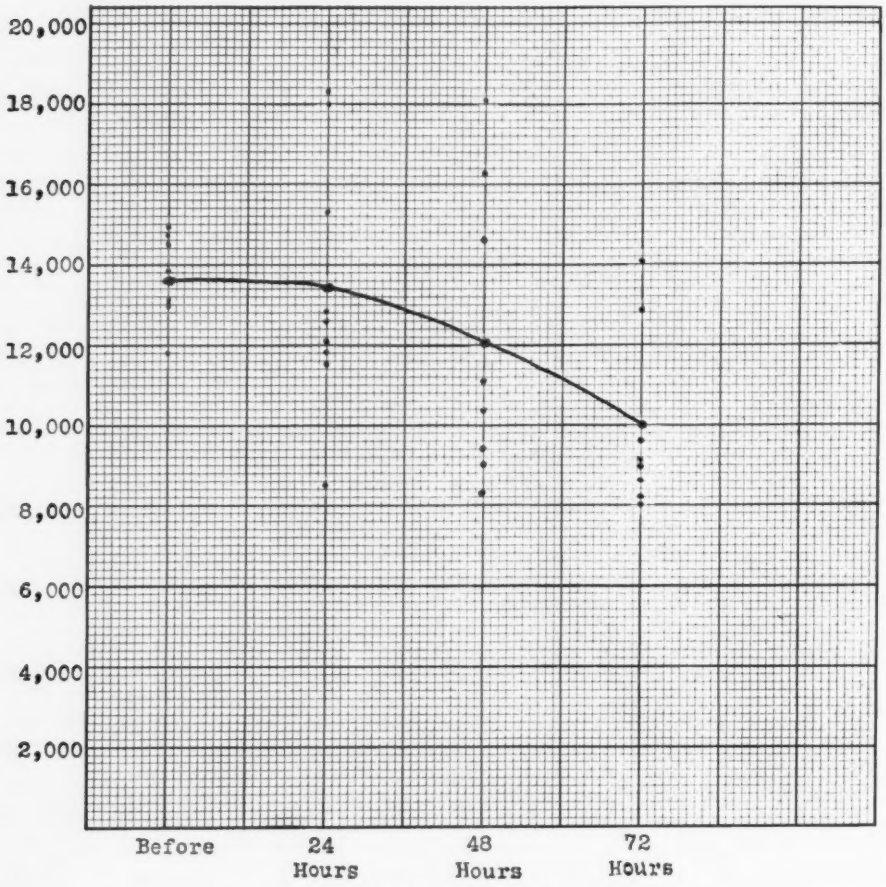

FIG. 4.—Acute cases saline solution.

average at the end of seventy-two hours being nearly 2,000 per cubic millimetre higher than before operation.

In the acute cases, the average cell count is highest before operation in both treated and control cases. Here again the fall in leucocyte count in the seventy-two hours following operation is more rapid and far greater in the treated cases than in the controls. It will also be noted that the greatest fall occurs after the first twenty-four hours. There is practically no change in the average cell count at the end of twenty-four hours in the control group.

In speculating on this quite constant phenomenon, two lines of argument are presented.

(1) The resistance to peritoneal trauma is greater when saline is introduced into the peritoneal cavity as evidenced by the sustained systemic leucocytosis. In defense of this point it is well known that an increase of leucocytes in the blood-stream is an indication that the organism is successfully combating its inflammation.

(2) Arguing conversely, along the lines of Johnson's research, it would seem that the Amfetin had speeded up the processes of repair and that the need for leucocytosis was more quickly overcome. Johnson and his associates believe the maximum benefit of Amfetin occurs about four hours after the injection. This factor may account for the delayed rise in leucocytosis in our group of non-acute cases, as all injections were done at the time of operation. If the Amfetin does speed up repair processes it probably does so by stimulating diapedesis of histocytes at the site of trauma.

CONCLUSIONS

(1) No further information is to be gained from these results in regard to the prevention of adhesions by Amfetin.

(2) The return of peristalsis after operations within the peritoneal cavity is not affected by the introduction of Amfetin.

(3) Post-operative abdominal pain and distention appear to be slightly more marked in cases treated with Amfetin.

(4) Post-operative nausea and vomiting seem to be lessened when Amfetin is used.

(5) Amfetin probably hastens the repair of the peritoneum following trauma.

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THE GASTRIC ULCER-CANCER PROBLEM

By Lyndon Holt Landon, M.D.
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Three o'clock in the dismal, gloomy afternoon of May 6, 1821. Six men, all physicians of questionable ability, one a mediocre anatomist, were gathered in a small, dimly lighted, green-painted room. In the centre, on a crude table, lay the cadaver which but a few hours before had been animated by the spirit of the greatest military and political figure of all time. Considering its world importance and historical significance, while allowing for the limited knowledge of gross pathology at the time, the official, as well as the individual reports, reveal that this autopsy was surprisingly superficial and inconclusive. It is stated in the protocol, and generally accepted, that Napoleon succumbed to carcinoma of the stomach. If so, there is every reason to believe from the known facts of his previous medical history that the cancer had been long antedated by a benign pre-pyloric ulcer. Years before his confinement to St. Helena, the Emperor had been subject to recurring gastric attacks, precipitated or aggravated by overwork, fatigue and fits of anger. The symptoms were apparently those of ulcer, marked pylorospasm, or both. From September, 1817, these discomforts became more or less continuous and increasingly severe up to the time of his death, three and one-half years later. It is quite as likely that death was due to the late complications, pyloric obstruction and marked gastritis of a large callous benign ulcer of the lesser curvature, previously leaking and later deeply penetrating into the liver. The absence of malignancy is somewhat substantiated by the preservation of an abnormal amount of superficial and intra-abdominal fat, by an apparently healthy liver, except where directly invaded by the ulcer, and by the fact that no mention is made of lymphatic involvement. Without the deciding service of microscopy, unavailable in 1821, the pathology in this case is likely to continue to be the subject for widely divergent speculation.

I have thus very briefly cited the salient facts in the case of the great French Emperor as an early example of the type which has led in our day to what seems to the writer to be, from the practical clinical viewpoint, a perfectly futile controversy between clinicians and pathologists, concerning the etiological relationship of benign ulcer to carcinoma of the stomach. I have no desire to add to the already burdensome literature with what would prove to be a purely academic discussion of this question.

While the incidence of secondary malignancy may not be so high as that first estimated by MacCarty, its undoubted frequency has been sufficiently proven to warrant its serious consideration in every case of ulcerative lesion of the stomach. The fact is often lost sight of, that carcinoma of the stomach is at least twice as, if not more, frequent than benign ulcer of this organ.

Benign ulcer probably occurs much less often than it is diagnosed upon subjective symptoms and unsubstantiated clinical findings even including appearances under Röntgen examination. "Ulcer" patients are notoriously wanderers, and there is no way of determining how frequently they apply to other clinics when the malignant nature of the lesion has become evident. Tracing the carcinomatous case backward to the clinical picture at least symptomatically of real or supposed ulcer, is much more convincing of the relationship of ulcer to cancer, or of that which is even of greater significance, the frequent confusing mimicry of early ulcerating cancer to benign ulcer, than any opinion to be formed from the attempt to follow up the average case with ulcer symptoms. To the writer, the real problem is not how many ulcers turn to cancer?, but how, if at all, can the early ulcerating adeno-carcinoma of the stomach be satisfactorily differentiated from the benign chronic ulcer? With our present clinical and laboratory armamentarium, not excepting the X-ray, and from sad experience, we are convinced that every ulcerating lesion of the stomach should be considered guilty of the suspicion of malignancy until proven innocent, and not that its innocence should be assumed until its insidious progress so frequently reveals its true character as cancer. Until now such early proof of the true nature of an ulcerating gastric lesion depends entirely upon the truths revealed by microscopical examination subsequent to its surgical removal. This attitude will be maintained until we are provided with some more accurate and reliable means than are now at our disposal for differentiating the innocent from the malignant ulcer at the time when the latter may lend itself to successful surgical eradication. While it has been most unjustly accused of being mainly the "offspring" of the "itching fingers" of the surgeon; of being a glaring example of unsafe and biased judgment, and as an expression of dangerous radicalism, this viewpoint to which we subscribe is fully substantiated by the unquestionable opinion of those who have had the widest experience with organic disease of the stomach. It is well to bear in mind that the suspicion, or even the possibility, of cancer is ample justification for measures which, seemingly radical to some, often prove to be the acme of conservatism.

The avoidance by authors of the all-too-inclusive terms, peptic ulcer, gastroduodenal ulcer, and parapyloric ulcer, and of combined statistics relating to the incidence, results of treatment, *etc.*, of ulcer of the stomach and duodenum, is desirable. By emphasizing the very distinct clinical entity of each of these lesions, much of the commonly existing confusion relating to their care could be avoided. About their only common characteristic is ulceration. The problems presented by each relative to their medical or surgical handling are, with few definite exceptions, exactly the reverse. Their potentiality toward secondary malignancy is diametrically opposed. Primary carcinoma of the duodenum is rare; secondary to benign ulcer it is practically unrecognized. It is admitted that duodenal ulcer is primarily a medical disease. There is a satisfactory unanimity regarding the indications for surgical intervention.

On the other hand, the more we encounter ulcer of the stomach, the more convinced we are of the advisability and necessity of its early surgical extirpation and that ulcer of this viscus should be from the start a surgical problem. The risk of procrastination in the case of those ulcers of the stomach which fail to give an immediate, satisfactory and continuous response to careful medical treatment cannot be overemphasized.

It is quite true that gastric ulcer frequently responds to medical regimen more readily than does ulcer of the duodenum, but experience has also shown that such early improvement is no proof of the benignity of the ulcer. Medical treatment in the presence of the early ulcerating carcinoma may likewise be followed by complete, but temporary, amelioration of subjective symptoms and in the disappearance of the clinical and laboratory findings, with the result that we are misled into a sense of false and dangerous security.

There is a certain group of gastric ulcer cases in which we feel that one is justified in recommending a definitely limited, meticulously controlled trial of medical treatment. This is largely dependent upon the type and duration of symptoms and upon the site of the lesion. The longer the previous duration of typical symptoms, at least a year or over, and the farther the ulcer from the pylorus, the safer is this advice. When closer to the pyloric ring, with but recent symptoms and especially if accompanied by lowered acidity regardless of the presence or absence of occult blood, the more hazardous becomes the delay in surgical exploration. The justification for the continuation of non-surgical treatment must depend entirely upon the results obtained within a strictly limited period. If within two months there has not been a definite diminution in subjective symptoms, a marked decrease in the size of the ulcer niche, clearly demonstrable by the Röntgen-ray, and the disappearance of occult blood by gastric analysis, medicine can no longer conscientiously assume the entire responsibility for the safety of the patient.

Even should such encouraging results obtain within the specified time limit, they do not warrant the assumption that the possibility of cancer has been definitely eliminated. Strict adherence to the medical regimen and continued improvement, supported by the results of at least monthly examinations by X-ray and gastric analyses, must maintain for at least a year before one can reasonably assert the benignity of the ulcer. If at any time there is a recurrence or change in subjective symptoms, a reappearance or enlargement of the ulcer niche, the return of occult blood, or a progressive subnormal gastric acidity, the welfare of the patient demands the immediate surgical exposure of the lesion. Only after such exposure can the further operative procedure best indicated, in the judgment of the operator, be determined for each individual case. We are not at present concerned in a discussion of the relative merits of, or the indications for, the employment of the various types of operation now at the disposal of the surgeon when confronted by the many mechanical and physiological problems incident to benign and malignant disease of the stomach. Suffice it to say that the success of modern gastric surgery is to a large extent dependent upon the good or poor judgment of the

surgeon in adapting the operation to the particular conditions revealed by his preliminary exploration.

It is an astounding fact that between 2 and 2½ per cent. of all deaths are due to cancer of the stomach. The human stomach is peculiarly susceptible to malignancy. Sixty per cent. of all carcinomas involve this organ, the breast, or the uterus, and of this number those of the stomach contribute nearly a half, approximately equaling those of the breast and uterus combined.

Gastric cancer untreated is invariably fatal. Cure is impossible and death of the host inevitable unless the growth is completely eradicated by surgical extirpation. Successful excision is possible only when the growth is still localized to an accessible, resectable part of the stomach. Operability and chances for cure of gastric cancer are inversely proportional to the positiveness of diagnosis. In other words, when the lesion has progressed to the point where the subjective symptoms, physical signs, and laboratory findings are unmistakable, the probability of cure has already vanished.

It is a most discouraging fact that when first seen by the surgeon, even exploratory operation is justified in but about 50 per cent. of cases, and in the patients operated upon, radical resection is feasible in probably not over one-third. The result is that, at present, between 98 and 99 per cent. of all patients afflicted with carcinoma of the stomach eventually die from the disease. This depressing state of affairs is mainly due to the great difficulties of, and consequent delay in, the positive diagnosis. There are no classical early clinical symptoms or findings in this disease. If we, when confronted by persistent symptoms of gastric disorder which do not favorably and adequately respond to medical therapy, await the appearance of probable tumor, emaciation, cachexia, coffee-ground vomitus, blood and tumor fragments in the gastric contents, we have usually waited until the doom of the patient has been inevitably sealed. If, on the other hand, the relatively safe procedure of surgical exploration were more frequently advised and accepted by the patient, I am confident that the mortality from cancer of the stomach would be greatly reduced.

A review of the records of our cases of carcinoma of the stomach encountered over a ten-year period has unfortunately thrown little, if any, helpful light upon the problem of the early diagnosis of this disease. It has served to strengthen our own opinion and to substantiate that of others if such were necessary, *i.e.*: (1) That every patient over forty years of age, with intractable gastric symptoms, should have not one, but frequently repeated careful Röntgen-ray examinations and these failing to clarify the situation within reasonable time should be subjected to exploratory laparotomy. (2) Every gastric ulcer is potentially malignant and failure of early and continuous medical control should be exposed surgically and dealt with according to the findings. (3) Positive proof of the true character of the early ulcerating gastric lesion is obtainable only through reliable microscopy.

During the interval from June 1, 1923, to June 1, 1933, there were 309 persons suffering from cancer of the stomach admitted to the various medical

and surgical services of the Western Pennsylvania Hospital. These cases accounted for about 0.3 per cent. of the approximately 100,000 patients cared for in the hospital during the same period. As would be expected, the males far exceeded the females in number; 199, or 64 per cent., of the patients were men, 110, or 36 per cent., women. This sex incidence is of no practical importance.

It is of importance to note that age is no decisive factor in the occurrence of gastric carcinoma. The average age for the entire group was fifty-four years. Our youngest patient was twenty-nine years of age, there were twenty-three under the age of forty, while the oldest patient was aged eighty-three. Significant, too, is the fact that no less than 100 of these cancers occurred in patients whose ages were between forty and fifty years. Forty per cent. therefore fell well within the so-called ulcer period, while 186, or 60 per cent., only were found in patients over the age of fifty.

The majority of the human race is so accustomed to varying degrees of gastric distress, labeled "indigestion" or "dyspepsia," that the early symptoms of carcinoma are not only difficult to elicit, but to evaluate, except in those instances when they parallel those of benign ulcer. Therefore, the early diagnosis based upon subjective symptoms alone is impossible. It has been stated by Ashhurst[2] and others that at first most patients complain of indigestion, loss of appetite, strength, and weight, and only later of epigastric pain. However, in the great majority of our cases, it happens that pain is recorded as having been the earliest symptom. It is probable, however, that when pain appears it overshadows in importance the memory of the milder earlier discomforts, and except in the cases of primary ulcerating carcinoma, or of those lesions producing early pyloric obstruction, pain is unfortunately a late manifestation.

Early characteristic pain with other symptoms and findings, including in many instances the results of Röntgen examination, had been sufficient to warrant the diagnosis of and treatment for benign ulcer in sixty-two, or 20 per cent., of our cases. It is stated in forty-seven, or 15 per cent., of the total number of records that for varying periods the pain had been relieved by food or alkalies. Probably no less than 25 per cent. of patients with gastric cancer, to their irreparable detriment, are treated in the early stages as cases of non-malignant ulceration.

The information obtained by gastric chemical analysis is unreliable as an early differentiating diagnostic factor in carcinoma of the stomach. Of the total number of our cases in which there is a record of the results of gastric analysis, in no less than 39 per cent. there was reported to obtain a moderately hypo-, a normal or a hypergastric acidity, and these findings were not obtained in the early, but almost entirely in the later, stages of the disease, as there were very few patients in our series in whom the disease was not quite far advanced when first seen. The presence of free hydrochloric acid in no wise mitigates against the diagnosis of cancer nor is its absence pathognomonic of this disease. So, too, the presence of lactic acid or the Oppler-Boas bacillus

are no indicators of the nature, inflammatory or malignant, of gastric obstruction. Occult blood in the stomach contents is simply evidence of ulceration but not of its character.

The duration of symptoms in gastric carcinoma is largely dependent upon the site and the peculiarities of the growth in the individual case. An infiltrating type of cancer may involve the stomach to a most surprising and hopeless extent before giving rise to any but insignificant symptoms. Occasionally there are no symptoms referable to the stomach and the malignancy is discovered only on routine Röntgen examination or surgical exploration. Therefore, according to the duration of clinical symptoms, patients with gastric carcinoma are clearly separable into three groups: (1) Those giving a long history of gastric distress (exceeding one year); (2) those with a history less than one year; and (3) those who, up to the most advanced stage, have experienced no symptoms of stomach disease.

The proportion of our cases falling into each of these groups corresponds closely to the numbers reported by others, such as Balfour,[1] Ashhurst and Klopp,[2] Blackford and Turner.[3] Thus in group (1), there were 119, or nearly 39 per cent., whose symptoms had existed for over a year. Of these, sixty-two gave a history exceeding two years, while in thirty-one, or 10 per cent., of the total number of gastric cancers, symptoms have been present for over four years. The longest duration of continuous dyspeptic symptoms was thirty years in a male patient aged sixty-four. He had suffered from indigestion, gas and epigastric pain; for the last six months from loss of weight and hæmatemesis. It is in this first group that the symptoms most often simulate those of a benign lesion, in which the diagnosis is so difficult or impossible, and among which we have a right to look for a definite lowering of the mortality from carcinoma of the stomach through earlier surgical intervention.

Group (2) was comprised of 60 per cent. of our patients, while but 1 per cent. fell into Group (3), those without the localizing clinical signs. It is for most of these patients that the outlook is so discouraging. While the diagnosis is usually evident, the disease has progressed so silently that satisfactory radical excision is possible in but relatively few instances.

While the Röntgen-ray has proved most valuable in determining the site and extent of involvement and in confirming the diagnosis in late malignancy, we feel that it cannot be relied upon, nor should it be expected to differentiate between the benign ulcer and the early ulcerating carcinoma, at the time when even the experienced pathologist is unable to do so by actual gross examination. Grossly and indirectly by the X-ray, the appearance of the two is identical. The diameter or "size" of the defect or crater has long since been discarded as a criterion. While the X-ray localization of the site of an ulcer as being at or near the greater curvature may increase one's apprehension of malignancy, the establishment of its position on the lesser curvature of the stomach is no indication of its benignity. The greatest diagnostic value of the Röntgen-ray in these early ulcerative lesions is in the accurate checking of the immediate and continuing results of trial medical treatment. There is

no doubt that in the clinical groups (2) and (3), the X-ray diagnosis of stomach cancer is correct in at least 90 per cent. of cases so examined, but in most of such patients, it is simply confirmatory of the opinion otherwise established.

The relative frequency of benign ulcer and carcinoma of the stomach is for various reasons difficult to accurately determine, but among patients hospitalized, the incidence of cancer far exceeds that of ulcer. During the ten years covered in the review of our cases of cancer, there are the records of 216 patients with the diagnosis of ulcer. As so frequently happens, a large number of these diagnoses were made upon the clinical symptoms alone without X-ray or operative confirmation. The common tendency toward the mimicry of ulcer symptoms by those due to functional disturbances and to various extragastric lesions is well recognized. It seems fair to assume the probability of there having been made an erroneous diagnosis in at least 25 per cent. of these cases, even without taking into account those which were later found to be malignant. In the hospital, therefore, the incidence of gastric malignancy is approximately twice that of benign ulcer, and justifies the suspicion which should be directed toward every organic lesion of the stomach.

Comparative statistics relating to operability, resectability, operative mortality, and end-results in gastric carcinoma are capable of so much distortion, are so variable, and so dependent upon the personal equation of the individual clinic, that they are difficult to interpret and practically valueless as a guide to others. This is clearly demonstrated in the most excellent paper by Ashhurst and Klopp.[2]

Our chief interest should be not in the number of patients upon whom only an exploratory or at best a usually unsatisfactory palliative operation is possible, but in the effort to increase the percentage of those observed early enough to permit a radical extirpation of the growth. The death rate from cancer will not be lowered until there is a more general appreciation of those symptoms or clinical findings which suggest the possibility of malignancy as well as recognition of the fact that positive clinical diagnosis of cancer of the stomach is possible only late in the course of the disease when the chances for its successful removal are most remote.

At present only about 50 per cent. of patients with stomach cancer are seen early enough to warrant even an exploratory laparotomy, while of those operated, in scarcely a half, or but 25 per cent. of the total number, is resection possible. Among our records of the 309 patients, there were 163 operations, of which thirty-nine were partial or subtotal gastrectomies, just over 12 per cent. of the total. Practically all of the author's personal series of nineteen subtotal gastrectomies for carcinoma have been done within the past five years, and it is too early to report the results. There were, however, three, or 16 per cent., early or so-called operative deaths. This, of course, does not include the resections done for benign ulcer and grossly suspected cancer in which the operative mortality has been much lower, *i.e.*, 4.2 per cent. As our experience has increased, so has the proportion of radical operations

even for palliative purposes. We have found that even rather extensive enlargement of the regional lymph-nodes does not always denote their malignancy, that they are often inflammatory, and if operation is mechanically possible, should not determine inoperability. Even in the presence of hopeless distal metastasis, subtotal gastrectomy, when possible, gives superior palliative results. In many cases, not resectable, transgastric exclusion of the distally involved portion of the stomach is a most valuable palliative procedure. In general we have found gastrojejunostomy affords little or no relief in gastric cancer and have in many cases personally deeply regretted having done it.

Probably 80 per cent. of patients suffering from acute appendicitis would recover from the attack without surgical intervention, although obviously there would result a much higher total mortality should the policy of withholding operation obtain until the appearance of late lethal complications made it mandatory. Few physicians have the temerity to persist in so hazardous a course. Possibly one-half of all breast tumors are clinically benign when first examined, but we all know that every discreet growth in the breast, regardless of the age of the host or physical appearance, is guilty of potential malignancy until proven otherwise by microscopy. By this attitude only has the mortality of carcinoma of the breast been reduced. None of us would longer condone the formerly frequent advice given to the patient with a nodule in her breast: "If it doesn't bother you, don't bother it." The subjective symptoms of chronic cholecystic disease may be long controlled as a smouldering fire by various therapeutic measures, only to break forth at last in an uncontrollable volcanic eruption as an acute pancreatitis or in the garb of one or more of its less immediate, but no less ominous, sequelæ—irreparable damage to the liver, pancreas and heart.

By the same token, early surgical exploration in the patient suffering from unaccountable symptoms indicative of organic disease of the stomach would, we are sure, be the most potent factor in the discovery of many carcinomas when still in the curable stage.

CASE REPORTS

CASE I.—No. 6391.—A man, R. D., aged sixty-three, was admitted to the hospital December 20, 1930, and discharged January 11, 1931. He complained of epigastric pain, gastric distress, and loss of weight. For twelve or more years there had been severe gastric discomfort, a sense of fullness, weight and gas. These symptoms had appeared rather constantly, about three hours after meals, and were relieved by taking food. He had never been nauseated nor vomited. For a long time daily enemas or cathartics had been necessary. Fifteen months before, weight loss began and in this interim had amounted to twenty-five pounds. For the past four months all gastric symptoms had become more constant and increasingly severe. For a long time he had been on a soft diet and rarely ate meats. There was nothing of importance found on physical examination excepting the moderate emaciation and the abdominal findings. There was visible gastric peristalsis and a small, freely movable, slightly tender mass, palpable at the pylorus, suggestive more of pyloric hypertrophy than of neoplasm.

Laboratory Examinations.—Normal blood, blood chemistry and urine. Gastric analysis: Total acidity, 70; free hydrocloric acid, 40; no blood. Röntgen examination done

prior to admission had shown moderate six-hour retention and what appeared to be a small ulcer niche on the greater curvature near the pylorus.

Operation.—The abdomen was opened through a high right rectus incision. The pylorus was distinctly the seat of muscular hypertrophy. There was no regional lymphadenitis. After considerable search, it was felt that there was a distinctly indurated area on the posterior wall just proximal to the pylorus. While deciding how to deal with the stomach, a small contracted gall-bladder, filled with stones, was removed. Partial gastrectomy completed by the Polya method was then done with no difficulty.

Immediate gross examination revealed a small, round, very shallow, punched-out ulcer, close to the pylorus. To both the attending pathologist and the writer, there was no gross evidence of malignancy and the ulcer was considered definitely benign. Later microscopical report: "Sections through the ulcer show a definite atypical epithelial proliferation at the margin of the ulcer, in places infiltrating into and beneath

FIG. 1.—(F) Floor of ulcer, denuded from epithelium. (C) Adeno-carcinomatous infiltration beneath the muscularis.

FIG. 2.—(F) Floor of ulcer, covered by atypical gastric epithelium. (C) Beginning adeno-carcinomatous infiltration.

the muscularis mucosæ. Part of the floor of the ulcer is covered with the atypical epithelial new growth (Figs. 1 and 2).

"It is not possible to decide with certainty if in this case one is dealing with a carcinomatous proliferation at the margin of a chronic ulcer or with an ulcerated carcinoma. The former possibility appears to be the more likely one. No metastatic lymph-node lesions were observed."

COMMENT.—It was fortunate that the close proximity of the lesion to the pylorus had caused early obstructive symptoms, largely due to pyloric spasm and hypertrophy. Resection was happily decided upon because of the age of the patient and definite evidence of an organic lesion. Up to the present this man has remained in good health and symptom-free. We were fortunate in having these slides examined later by Dr. James Ewing,[4] who expressed his

opinion that this lesion was not only definitely malignant but had been so from the start; that it was an early ulcerating carcinoma. Verse[5] was the first to call attention to and describe these early ulcerating superficial carcinomas of the stomach, nearly always occurring close to the pylorus, and their close similarity to benign ulcer. I know of no means clinically or grossly, even after its removal, of distinguishing between this cancer and a non-malignant lesion. This is the earliest malignancy of the stomach that I have observed.

CASE II.—No. 3033.—J. W. C., male, aged thirty-seven, was admitted to the hospital September 25, 1933, and discharged January 9, 1934. He had always been subject to mild digestive disturbances. Five months before admission he began to have attacks of severe epigastric pain of a gnawing, boring character. This pain was always relieved by food and alkalies and was always augmented when hungry. No nausea or vomiting. At times he would be awakened at night by the gnawing pain. He would get up and get something to eat for relief. He was being treated for duodenal ulcer and under diet and alkaline treatment has been somewhat relieved and had gained weight. His weight was then 180 pounds. Lately, however, the symptoms had increased and he had gotten weaker. Much of his condition he attributed to large bleeding hæmorrhoids, present for the past two or three weeks. Except for slight epigastric tenderness, nothing of importance was discoverable upon physical examination. There was, however, a marked anæmia: red blood-cells, 3,180,000; hæmoglobin, 55 per cent.; white blood-cells, 9,200; polymorphonuclears, 77. There were moderate anisocytosis and numerous microcytes with occasional poikilocytes. October 2, gastric analysis showed no hydrochloric acid in any specimen. Röntgen examination of the stomach September 27, 1933, revealed a rather large stomach with active peristalsis and slow emptying. There was marked tenderness in the pre-pyloric region and a constant filling defect in this region. The appearance was more suggestive of polyps or hypertrophied rugæ than of an ulcer. At six hours there was some gastric residue. The diagnosis of gastric ulcer was made and the patient continued on the indicated treatment without improvement. He was seen by the writer in consultation October 23, 1933, when the opinion was given that we were dealing with an adeno-carcinoma of the stomach and immediate operation was advised. However, the X-ray examination was repeated which showed a much larger filling defect than previously noted. At this time most of the antrum was involved and there was a much larger six-hour gastric residue. The opinion was given that the antral lesion was increasing, that slight obstruction was present, and that the appearance was more suggestive of a malignant new growth than a benign one. There was still no area typical of an ulcer and if one was present, it must have been on the posterior wall.

After some difficulty operation was consented to and October 28, the abdomen was opened. An ulcerating carcinoma, eight centimetres by eight centimetres, involving and partially obstructing the pylorus, was revealed. It was densely adherent to the pancreas with widespread regional metastasis. Palliative operation was decided upon and a posterior gastroenterostomy performed.

COMMENT.—This patient was but little relieved by gastroenterostomy and died at home February 14, 1934. It is probable that greater relief would have been given by a transgastric excluding section of the stomach, and that by this procedure his life, if not prolonged, would have been made more bearable. This case is illustrative of the early ulcerating adeno-carcinoma occurring at the pylorus, running a rapid course, and frequently in its early stages,

particularly in the young individual, indistinguishable from gastric ulcer, although in this instance the early achlorhydria was most suggestive of the gravity of the situation.

CASE III.—No. 7160.—Mr. C. F., aged fifty-one, was referred to my service at the hospital February 8, 1932, and discharged March 5, 1932. He came for the relief of severe epigastric pain and hæmatemesis. The previous day he had had an empty gnawing sensation in the epigastrium; he was unable to sleep, felt restless and weak. The morning of admission he vomited a large quantity of bright red blood and weakness increased. For over three years this man had had recurring attacks of epigastric pain occurring either directly or one to two hours after meals. At first some relief was afforded by peppermint water. No experience with soda. Eight months before there had occurred a profuse gastric hæmorrhage requiring blood transfusion. After this he was treated for gastric ulcer, said to have been shown by X-ray, with almost complete relief and a gain of twelve pounds in weight. Six weeks before, there had been a recurrence of symptoms. By January 15, 1932, he was free of symptoms and gastric analysis showed a total acidity of 56; free hydrochloric acid, 28, in one hour. No blood in specimens. X-ray examination at this time showed apparently a definite ulcer in the distal third of the lesser curvature.

With the exception of moderate epigastric tenderness, general physical examination was essentially negative. There was a moderate secondary anæmia. Urine and blood chemistry normal. The diagnosis of bleeding chronic gastric ulcer was made.

By February 17, the patient's condition had so improved as to warrant operation. Upon exposure, the round ligament was found firmly adherent to a thickened indurated area on the anterior surface of the stomach, three centimetres proximal to the pylorus, which was the seat of an indurated ulcer two centimetres in diameter. Posteriorly, the stomach at this point was densely adherent to the pancreas. The stomach wall throughout was definitely thickened and the mucosa markedly hypertrophied. A few subpyloric lymph-nodes were found involved. A partial gastrectomy, including all the lesser curvature, was performed by the Polya technic.

Pathological Report.—The removed portion of the stomach presents a circular ulcer three centimetres in diameter and 1 centimetre deep. The edges are sharply defined and elevated, the floor is granular and hard. The gastric mucosa appears hypertrophic.

Microscopical.—While the floor of the ulcer shows a zone of necrotic tissue resting on a broad zone of chronic inflammatory connective tissue, in most parts the necrosis has evidently taken place in a small cellular "diffuse" carcinoma. The latter extends through all coats of the gastric wall. It is associated with marked plasma cellular and eosinophilic leucocytic infiltration as well as new formation of connective tissue. The adjoining gastric mucosa is the seat of a marked hypertrophic gastritis. The submucosa is infiltrated by the "diffuse" carcinoma.

Diagnosis.—Ulcerating "diffuse" carcinoma of the stomach.

CASE IV.—No. 6320.—M. T., aged fifty-six, was admitted to my service from the out-patient department January 6th, 1932, and died January 27, 1932. He had been referred to the dispensary October 21, 1931, by his family physician, complaining of localized pain in the epigastrium, present for over a year. During this time he had lost fifteen pounds in weight. The pain occurred two to three hours after eating, knife-like in character, and was frequently, but not always, relieved by food. There was also frequent nausea, a burning sensation in his throat and sour regurgitation of food, but no vomiting. Health had always been good prior to the year before.

In the dispensary, with the exception of some loss of weight and moderate epigastric tenderness, physical examination was negative. At this time the blood was found normal; urine negative. Gastric analysis showed a total acidity of 24; free hydrochloric acid, 0, positive for occult blood. October 21, 1931, X-ray examination: "Stomach

tender in mid-gastric region. There is a typical ulcer niche on the lesser curvature. No other pathology noted." The patient was placed on the medical treatment for ulcer with complete subjective relief. December 17, 1931, he was again examined by X-ray when it was found impossible to identify the ulcer niche previously noted, either under the fluoroscope or by films, although there still remained a small six-hour residue and tenderness over the lesser curvature. It was considered a case of gastric ulcer. By January, however, there was a return of symptoms. At that time, except for definite tenderness in the right epigastrium, nothing was demonstrable physically. There had been little loss in weight. January 8, 1932, fluoroscopical examination of the stomach was repeated. Now the defect on the lesser curvature was not only demonstrable but had greatly increased and there was intense spasm involving both greater and lesser curvatures.

Operation.—January 26.—An exploratory operation was done. A huge carcinomatous growth involving the lesser curvature of the stomach, adherent to the under surface of the liver, was exposed. Attempts to separate the stomach from the liver resulted in a tear into the lumen of the stomach and further attempts at resection were abandoned. The gastric tear was sutured and the abdomen closed. Death occurred the following day.

COMMENT ON CASES III AND IV.—Neither the subjective symptoms nor the clinical findings were sufficient to establish the diagnosis in either of these cases at the time when the cancer might have been most successfully resected. Further delay was occasioned in both by the misleading subjective and clinical improvement following medical ulcer treatment. While in the first patient resection was accomplished, as yet the prognosis is extremely unfavorable. These cases exemplify the importance of more frequent X-ray check-up and the dangers in relying alone upon the subjective relief and general improvement under medical treatment for supposed gastric ulcer. They also emphasize the difficulties, if not the impossibility, in differentiating between early ulcerating carcinoma and benign ulcer. There is no reason for believing that in either of these patients, the lesion was anything but carcinoma from the start.

CASE V.—No. 3251.—Mr. R. O., aged sixty-two, thought that he had been in good health up to five weeks prior to his admission to the hospital September 19, 1927. He was found to have a nearly complete pyloric obstruction, food eaten a week previously being recovered by lavage, while the X-ray revealed the retention of a barium meal, given elsewhere, over seventy-two hours before he came to us. A firm movable mass could be easily felt in the region of the pylorus. He was extremely emaciated and in a state of starvation. September 23, the abdomen was opened. The malignant tumor was found directly at the pylorus and completely obstructing it. While the stomach and tumor were easily delivered and were free from any adhesions, there were enlarged lymph-nodes along both gastric curvatures. There was no other discoverable metastasis. The general condition of the patient at the time prohibited resection and a posterior gastrojejunostomy was done. Immediate improvement was so marked that by October 12 a partial gastrectomy was easily accomplished. At this second operation, the enlarged lymph-nodes previously noted had entirely disappeared. Apparently their involvement was wholly inflammatory, secondary to the deep ulcerating cancer crater. Infiltration of this adeno-carcinoma extended for one centimetre beneath the apparently intact mucosa of the pylorus. The patient was discharged from the hospital in excellent condition November 5, 1927, and at the end of five years was symptom-free.

COMMENT.—The case illustrates the advantages of the two-stage operation in many cancers involving the pyloric ring. By so doing, we not only minimize

the immediate risk of the more radical operation, but permit of the subsidence of the local infection and intense gastritis, the not infrequent causes of fatalities following partial gastrectomy. It has been our experience that in most instances, the results following gastroenterostomy in the case of carcinoma have been most disappointing, certainly when done as a palliative procedure. The only cases where it is reasonably satisfactory are those where the lesion is at the pyloric ring and has produced marked obstruction. When confronted by inoperable cancer of the stomach, in which no other palliative operation is possible, the author ordinarily is convinced of the futility and keenly senses the injustice of gastroenterostomy. As illustrated in this case, lymph-node involvement in ulcerating carcinoma is by no means necessarily malignant and should, when regional, be considered no deterrent to radical extirpation.

Case VI.—No. 7947.—L. F., male, aged thirty-eight, was referred April 12, 1934, and discharged from the hospital May 11. He complained of severe epigastric pain, vomiting and loss of weight. For ten years he had suffered from epigastric discomfort and occasional pain, occurring one to three hours after meals, relieved by food and baking soda. For three years his symptoms had become more frequent and severe, with repeated vomiting of dark-colored "coffee-ground" fluid. At times the stools were tarry. He had been on a milk diet for two years. In December, 1933, he was operated on elsewhere for duodenal ulcer. He was told no evidence of ulcer was found. His symptoms had continued unabated. In the past six months he had lost twenty pounds in weight. Except for general emaciation, weakness and definitely localized epigastric tenderness, physical examination revealed nothing of importance. Gastric analysis was refused and not insisted upon. There was moderate secondary anæmia. The Röntgen examination showed the stomach to be large and atonic with no evidence of peristalsis. There was a large projection on the lesser curvature side of the pylorus that suggested a large penetrating ulcer. Almost complete retention with 50 per cent. residue at twenty-four hours. After repeated gastric lavage and intravenous administration of glucose and saline solutions, operation was undertaken April 23. There was a large saddle ulcer occupying the distal third of the stomach, surrounded by widespread adhesions and posteriorly densely adherent to the pancreas. A partial gastrectomy, including all the lesser curvature and the distal two-thirds of the greater, was accomplished. The patient made an uneventful recovery following a necessary post-operative transfusion.

Pathological Report.—Portion of stomach ten by six by one centimetres. There was an ulcer four centimetres in diameter, extending through the entire stomach wall. The margins of the ulcer were composed of tough white tissue. The stomach wall showed a marked hypertrophy of the muscular coat. Microscopically, a chronic gastric ulcer with no evidence of malignancy.

Comment.—While favoring the diagnosis of benign ulcer, I know of no means by which, clinically, malignancy could be definitely excluded pre-operatively. Microscopy only determined the innocence of this ulcer. Incidentally, the size of this benign ulcer serves to further controvert the now generally discarded idea that the size of the crater is any criterion of the nature of the lesion. It is obvious that this ulcer was present at the time of the exploratory laparotomy only four months prior to the gastrectomy.

Case VII.—No. 1930.—Miss A., aged fifty, was referred to my service July 26, 1929. She was discharged August 25, 1929. So far as she knew she had been perfectly well with no gastric distress until three weeks before. At that time the patient began

to experience epigastric pain, mostly continuous, accompanied by occasional vomiting, but having no relation to food intake. Soda afforded no relief. A week before admission the pain became greatly intensified, she fainted, was in shock, and the abdomen was rigid and tender. She was treated by her family physician who later X-rayed the stomach. The writer examined these X-ray plates. There was a marked hour-glass constriction and a deep penetrating ulcer at the middle of the lesser curvature. Obviously we were dealing with a perforated penetrating ulcer of the lesser curvature, in which at least the suspicion of malignancy was justified. Gastric analysis showed total acidity of 44, free hydrochloric acid of 10. At operation July 28, a large previously perforated ulcer penetrating the liver was exposed. Grossly it was benign. The ulcer was one centimetre in diameter, punched out, with rounded overhanging margin. A sleeve resection was done. The patient made an unusually smooth recovery and has remained in good health to the present time. Pathologically there was no malignancy.

COMMENT.—This case is included, not to show the efficacy of the surgical treatment of benign ulcer. The age of the patient, the short duration of symptoms, the clinical and laboratory findings, certainly paralleled those encountered in innumerable cases of gastric malignancy. Microscopy of the removed specimen was the only final deciding factor.

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THE USE OF PERITONEUM IN THE REPAIR OF INGUINAL HERNIA

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The incidence of recurrence of inguinal hernia has remained relatively high in spite of the various modifications of the Bassini operation. The contribution of Gallie[1, 2] who suggested the use of fascial sutures has been the outstanding contribution to this field of surgery in the past decade.

It is generally accepted that three fundamental principles are involved in the radical cure of hernia: (1) high ligation of the sac; (2) adequate reënforcement of the abdominal wall; (3) primary wound healing. Of these the first and third can be readily dealt with. The second factor, however, is not always so easy to attain and maintain.

The experimental work of Seelig and Chouke[3] support the conclusion of Gallie, Andrews[4, 5] and others that the approximation of white fascia to white fascia is essential in order to obtain satisfactory closure of the defect. This fact is generally accepted but in order to attain the objective it is often necessary to obtain fascia at a distance from the primary operative wound.

Following somewhat the plan of Gratz,[6] who studied the tensile strength of the human fascia lata, I undertook at the suggestion of Doctor Ravdin to measure the tensile strength of various fasciæ in dogs and to compare these observations with similar studies made on the tensile strength of the peritoneum of the same animals. It seemed possible that some structure readily available in certain types of herniæ might prove satisfactory for use in the reënforcement of the abdominal wall.

Method.—Pieces of rectus fascia and of the fascia lata were removed and cut to uniform size with a die. Similarly, pieces of the peritoneum from the same animal were cut for study. The machine used was a modification of the standard tensile strength apparatus modified to meet our needs by Rawson of the Johnson Foundation for Medical Physics. Attempts were made to determine the thickness of the tissue removed for study but the thinness of the peritoneum prevented accurate measurement by the method used.

Results.—Stress-deformation diagrams were not charted but the figures quoted are the ultimate strength figures, *i.e.*, the maximum load the piece carried before breaking (Table I).

Gratz found that fascia lata had surprisingly great tensile strength, comparing favorably with soft steel wire of the same weight. The fascia lata showed its greatest strength only in the direction of its fibres.

The data here reported confirms Gratz's observations in that they show that the fascia lata possesses surprisingly great tensile strength. While the data on the tensile strength of the peritoneum are not nearly so good as those

TABLE I

Type of Tissue	Maximal Tensile Strength	Direction of Fibres
Fascia rectus	2.83	Transverse
Fascia rectus	2.45	Transverse
Fascia lata	2.45	Transverse
Peritoneum	.25	Vertical
Fascia lata	4.20	Transverse
Peritoneum	.29	Horizontal
Fascia lata	5.65	Parallel
Fascia lata	3.88	Transverse
Peritoneum	.23	Vertical
Peritoneum	.22	Horizontal
Peritoneum	.25	Vertical
Peritoneum	.29	Horizontal
Peritoneum	.25	Vertical
Peritoneum	.29	Horizontal
Fascia lata	7.30	Parallel
Fascia lata	3.22	Transverse
Fascia lata	3.81	Parallel
Fascia lata	2.00	Transverse
Peritoneum	.20	Vertical
Peritoneum	.26	Horizontal

of fascial structures they show considerable tensile strength when one considers the thinness of the structure used. Had various fascial coverings such as surround the sac of an indirect inguinal hernia been present the tensile strength would have been much greater.

The second problem was to determine whether the peritoneum when used as suture material would unite with fascia and muscle. Utilizing the technic of Seelig and Chouke the following experiments were made on dogs:

Dog No. 220.—Operated on, October 24, 1932. An incision was made in the right fascia lata about two inches long. A strip was excised to use as a suture, one fascial edge was then turned back to resemble Poupart's ligament. The strip of fascia was then transfixed through the edge of Poupart's and through a traumatized tunnel in the muscle. A piece of peritoneum taken from a mid-abdominal incision was used similarly a few centimetres proximal to the fascial suture (Fig. 1).

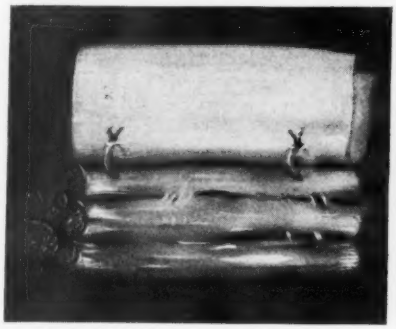

FIG. 1.—Sketch of operative procedure used.

On November 9, 1933, the dog was killed. An incision was made through the fascia lata, and a piece of fascia lata and the muscle containing the two strips of suture material, one fascia lata, the other peritoneum, were blocked out intact. Grossly, it appeared as if both bands were firmly attached to the muscle. Microscopical sections were made (Figs. 2 and 3).

Dog No. 240.—Operated on, November 14, 1933. The fascia lata of both lower extremities was exposed through semilunar skin incisions. The skin was dissected up and an artificial Poupart's made. On the right side peritoneal strips were sutured into

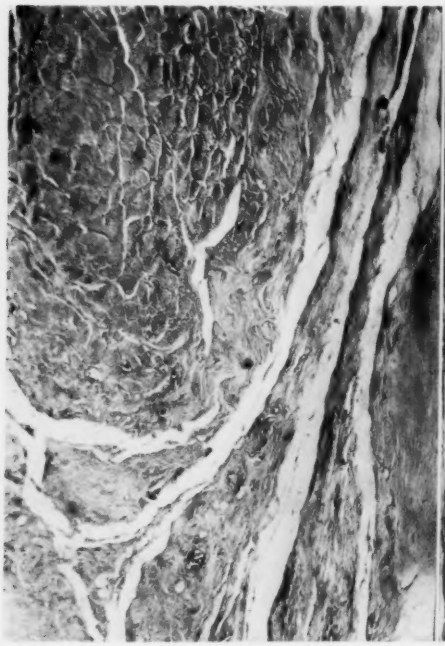

FIG. 2.—Peritoneum united with fascia and perimesium of muscle.

FIG. 3.—Fascia united with fascia and perimesium of muscle.

this newly made ligament through a muscle tunnel and on the left side fascia lata strips used. This dog developed an infected wound, although apparently not severe, but the dog died in two weeks. While it looked as if union had taken place on both sides, microscopical sections were not made.

FIG. 4.—Sketch of site of peritoneal sutures.

Dog No. 437.—Operated on, December 19, 1933. Three peritoneal sutures, the peritoneum being taken from the thinnest portion of a mid-line incision, were used as sutures in the manner already described.

On January 16, 1934, the dog was killed. There was apparently firm union between the peritoneal sutures and the fascia (Fig. 4), as well as some union to the muscle. Microscopical sections were made (Fig. 5).

Dog No. 516.—Operated on, January 9, 1934. A strip of fascia lata, two centimetres wide, was removed from each side. On the right side a strip of peritoneum about one-half centimetre wide was pulled through a traumatized tunnel in the muscle, three centimetres long. Black silk sutures were used at both ends to fix it and to help localize it later on. On the left side a similar tunnel was made but nothing put through, the ends of the tunnel being marked with silk

sutures. On February 8, 1934, the dog was killed and sections made of the two areas. The point of entrance of the peritoneum into the muscle tunnel (Fig. 6). There has been considerable proliferation of fibrous tissue. Where no peritoneum was introduced the section showed only a slight scar.

SUMMARY.—It has been shown that the peritoneum has sufficient tensile strength so that it may be utilized in the repair of certain inguinal herniæ. The experiments further show that peritoneum will unite with fascia and when it comes in contact with the perimesian of muscle, will unite with it in a similar manner as does the fascial suture. It is suggested that the hernial sac, which now is discarded, be used in operations where the indications exist for reënforcement of the abdominal wall.

FIG. 5.—Peritoneum united with fascia and perimesium of muscle.

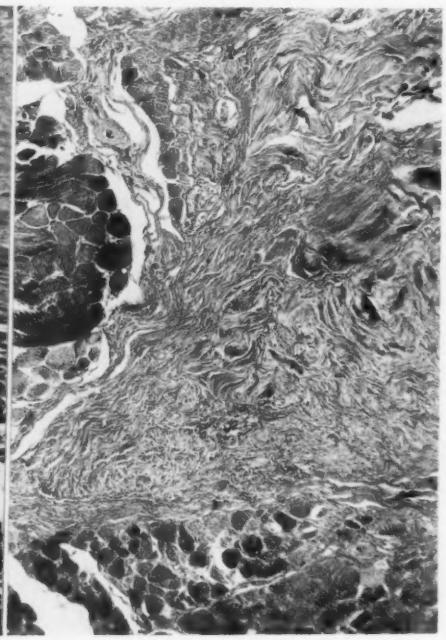

FIG. 6.—Peritoneum united to perimesium of muscle.

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INTESTINAL ULCERATION FOLLOWING ADRENAL DAMAGE

EXPERIMENTAL OBSERVATIONS

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Data previously presented[1] demonstrated the high frequency of intestinal ulceration which followed bilateral partial destruction of the adrenal glands. In a series of twenty-one dogs, definite ulceration was found in the small intestine in seventeen at autopsy, being most marked in the duodenum, but also present in the jejunum and the upper part of the ileum. In no instance was any evidence of gastric ulceration found.

The ulceration was of two distinct types. In ten animals the ulcers were of an acute type, appearing as superficial circular or ovoid areas of mucosal destruction with clean punched-out borders extending only partially through the mucosa. The mean length of life following injury to the first adrenal gland in this group of animals was 17.5 days.

Seven of the seventeen animals presented definite circumscribed ulcers of a more chronic type with heaped-up edges and excavated craters at autopsy. These ulcers appeared in the duodenum, jejunum and upper ileum but none was observed proximal to the pyloric ring. Histologically, they were seen to extend down to the muscularis mucosa, but there was no evidence of penetration of this layer. Congestion of the duodenumal mucosa, varying in degree from marked blushing to frank hæmorrhage, was observed in six animals. The mean period of time in this group from damage of the first adrenal to sacrifice of the animal was 24.5 days.

At the time these studies were completed, and just before their publication, Cushing[2] published an excellent paper on "Peptic Ulcer and the Interbrain" in which a thorough review of the neurogenic theory of ulcer was presented. He postulated that, "So far as the stomach is concerned, on this working basis of imbalance between the sympathetic and parasympathetic systems, it is known that vagal stimulation causes increased motility and secretion, whereas sympathetic stimulation gives reversed effects; and as a natural corollary, vagal paralysis diminishes secretion and motility whereas sympathetic paralysis increases them, presumably by releasing the vagus from the check normally exercised by the sympathetico-adrenal apparatus against its overaction."

Subsequently we had the opportunity of showing our experimentally produced ulcers to A. D. Keller, who, with Hare and D'Amour[3] had reported the production of gastric and duodenal ulceration in a series of cats and dogs which had either hæmorrhage into the ventricular system or transverse lesions at the level of the chiasm unassociated with intraventricular hæmorrhage.

The similarity between the ulceration obtained by Keller and his associates and that which we had produced together with the observations of Cushing led us to extend our investigations in an effort to determine whether the type of ulceration which followed adrenal damage, and which we believe is similar to the Curling ulcer, has any relation to an existing sympathetic-parasympathetic imbalance.

EXPERIMENTAL DATA

Dogs were again used as the experimental animal and a group of seven were subjected to bilateral abdominal vagotomy, the vagi being divided as they came through the diaphragm. Because of technical difficulties, the question arose as to whether all the vagal fibres were being sectioned by this approach. Accordingly, the right vagus of each dog was sectioned in the neck to remove as far as possible the vagal influence to the upper gastro-intestinal tract. Six dogs survived the combined operative procedures and were subjected to bilateral adrenal cauterization using a high-frequency coagulating current after the method previously described. These animals with one exception remained in good health and were sacrificed and immediately autopsied at intervals varying from two weeks to thirteen months after completion of the operative procedures.

FIG. 1.—Duodenal and jejunal ulcers resultant from bilateral adrenal cauterization following section of both vagi.

The animal which succumbed two weeks after vagotomy without adrenal cauterization showed no congestion or ulceration in the intestinal tract at autopsy. The second dog, which died one day following bilateral adrenal cauterization, showed intense congestion of the duodenal mucosa, beginning at the pyloric ring and extending down into the upper jejunum. This finding was similar to that noted in six animals in the original series which succumbed soon after adrenal cauterization.

The remaining five dogs continued in good health, maintained their weight, and evidenced no ill effects from the operative procedures. At autopsy nothing abnormal was noted in the stomach of any of them. Numerous superficial ulcers were noted, however, in the duodenum and upper jejunum of two dogs, while the remaining three dogs had ulcers of a more chronic type with heaped-up edges and excavated craters (Fig. 1).

These ulcers varied in number from two to six and were seen chiefly in the duodenum just distal to the pyloric ring and in the upper jejunum. In none of this group was there

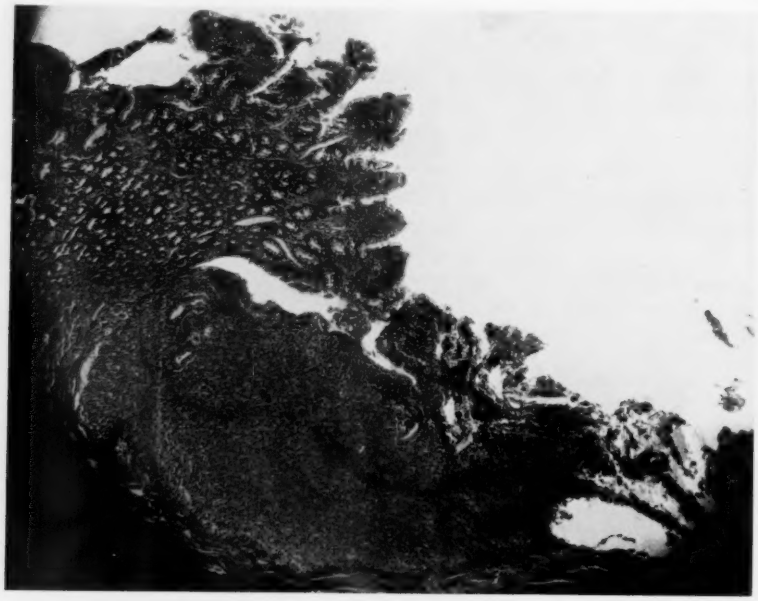

FIG. 2.—Section taken through edge of a chronic duodenal ulcer demonstrating the character of the overhanging ulcer wall and the absent mucosa in the base of the ulcer.

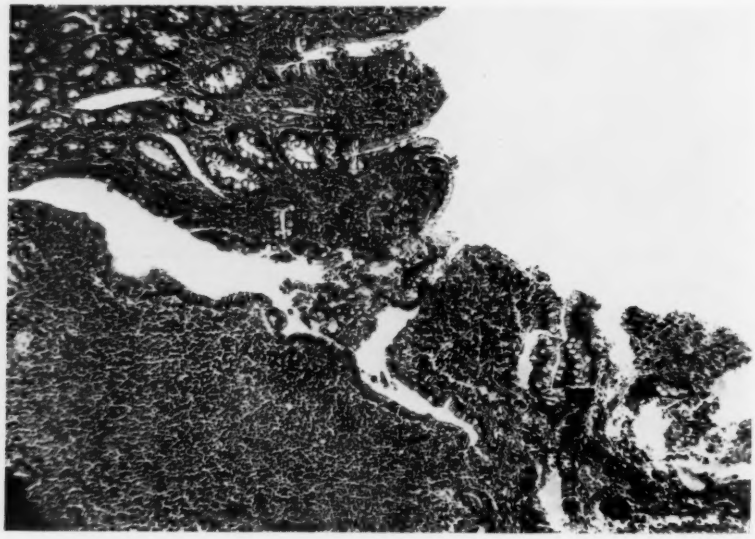

FIG. 3.—Higher power photomicrograph through the upper edge of an experimentally produced duodenal ulcer showing the intact epithelium in this area.

any evidence of marked mucosal hæmorrhage or congestion. On gross and microscopical examination the ulcers were identical with those which we had previously produced following bilateral adrenal cauterization without section of the vagi (Figs. 2 and 3).

DISCUSSION

The concept that gastro-intestinal ulceration may be incident to some neurogenic factor is by no means a new one. Almost a century ago Rokitansky[4] ascribed certain gastric lesions to "diseased innervation of the stomach, owing to a morbid condition of the vagus and to extreme acidification of the gastric juices."

Stimulated no doubt by the views of Rokitansky, a group of workers, including Zironi,[5] Lorenzi,[6] Van Yzeren[7] and Ophuls,[8] have reported the production of gastric ulceration in rabbits following bilateral subdiaphragmatic vagotomy. These results have not been entirely confirmed by subsequent observers.

Durante,[9] in 1916, attacked the problem from a slightly different angle. By section of the median splanchnic nerve, he was able repeatedly to produce gastric and upper duodenal congestion and ulceration, associated with hæmorhage into the adrenal on the affected side. He was unable to reproduce this picture when the greater or lesser splanchnic nerves were sectioned, and concluded that the results obtained following median splanchnic nerve section were due to irritation of the nerves to the adrenal medulla with a subsequent outpouring of adrenalin, constriction of the vessels to the intestinal mucosa, hæmorrhage, and finally ulceration.

Out of the maze of conflicting reports one finds it difficult to draw any definite conclusions. After an exhaustive study of the literature on the subject, Cushing[2] came to the conclusion that "the peripheral lesions which have led with the greatest constancy in the laboratory to ulcerative lesions have either been paralytic on the part of the sympathetics or stimulatory on the part of the vagus." Strong clinical evidence is offered by him to prove the existence of a parasympathetic centre in the interbrain, irritation of which may produce ulcerative lesions in the upper intestinal tract acting through the vagus. This supposition is supported by the work of Light, Bishop and Kendall,[10] who have produced similar intestinal lesions following the injection of pilocarpine into the lateral ventricles of animals. Beattie[11] has recently reported the production of hyperæmic patches in the gastric mucosa following the direct electrical stimulation of the tuber cinereum of animals.

In our experiments there can be little doubt that the intestinal ulceration is due to damage of the adrenals. If the lesions which have been produced by adrenal damage were in any manner associated with a decrease in the sympathetic tonus and thereby an overactivity of the vagal control, abolition of the vagal influence should prevent ulceration in the intestinal tract. The results obtained in the present experiments do not substantiate the vagal concept of ulceration as applied to the ulcer which follows adrenal injury.

If a sympathetico-parasympathetic imbalance is associated with the ulceration which follows adrenal damage, it is more likely that the ulceration is the result of sympathetic overactivity. Greenwald and Eliasberg[12] have demonstrated a marked hyperglycæmia following superficial burns, lesions which are known to produce adrenal injury.

The exact mechanism by which sympathetic overstimulation might produce duodenal ulceration rather than gastric ulceration is as yet speculative. It would seem more likely at this time that a humoral rather than a primary nervous factor must be invoked to explain the type of ulceration which we have observed.

CONCLUSIONS

(1) Further experimental evidence is offered that partial adrenal damage produces duodenal and jejunal ulceration.

(2) Bilateral vagal section apparently does not prevent the development of the intestinal ulceration which follows adrenal cauterization.

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RECURRENT EMPYEMA THORACIS

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The recurrence of empyema some time after its apparent healing has received scant attention in medical literature. Were one to judge its importance and frequency by the number of articles written on the subject, and by the rare mention, even in works on thoracic disease, of its possibility, one would be led to the conclusion that it was of unusual occurrence and of no importance. The reappearance of an empyema at a long interval after its apparent cure is not commonly encountered, but it is far from being a rarity. Hedblom,[1] in 1923, was able to report on ninety such cases seen at The Mayo Clinic in a five-year period. These were included in a series of 310 cases of chronic empyema, but the proportion of these to the total number of empyema cases is not given. In a study of the empyema cases admitted to the surgical services of the Episcopal Hospital and the Hospital of the University of Pennsylvania in Philadelphia, over a twenty-year period only fourteen recurrent cases were found among 869 cases of acute and chronic empyema. The marked discrepancy between The Mayo Clinic series and our own can be reconciled when one remembers that The Mayo Clinic has a high percentage of chronic cases, whereas the figures in the Philadelphia series represent the cases found in two urban hospitals handling the usual run of acute and chronic cases.

Before studying the series of cases included in this report, letters were sent to a number of surgeons having wide experience in the treatment of empyema. Their answers varied greatly. One could recall only one case of recurrent empyema. Another, on the staff of a large municipal hospital, replied that he saw a number every year, whereas others reported seeing them occasionally. The importance of this condition lies in the fact that it is so seldom considered that a large percentage of the cases go unrecognized until spontaneous drainage occurs through a bronchus or the chest-wall. The symptoms preceding this occurrence are usually vague, and unless one bears in mind the possibility of recurrent empyema, the true condition will be overlooked, and much valuable time will be lost.

In the standard books on general and on thoracic surgery scant mention, if any, is made of the recurrence of empyema. Even Sauerbruch,[2] in his monumental work on the surgery of the chest, fails to consider this problem. Although a search of the vast literature dealing with empyema probably would reveal discussions of recurrence, few articles could be found which were primarily concerned with this subject. In 1841, Sedillot[3] in his thesis entitled "De l'Operation de l'Empyeme" included the report of a case of

empyema recurring twenty-two years after apparent cure, the abscess pointing in the original operative scar. Fifty-one years later, Ayer,[4] of Boston, reported a case in which recurrence took place two and a half months after apparent cure, but here also recognition of the condition was not made until the chest-wall became involved. Samuel West,[5] in 1895, presented a case in which there was an interval of eight years of perfect health between the first and second attacks of empyema. At the second operation the empyema cavity was found to be limited posteriorly by adhesions in the region of the old operative scar. West believed the rarity of recurrence to be due to the obliteration of the pleural space in the usual case of empyema. He felt that recurrence could occur only when the original process was localized. Pryor,[6] in 1907, noted the scarcity of published information about this subject, described a case of his own, and discussed the etiology and diagnosis with particular reference to the great value of exploratory aspirations. The first series of cases to be reported in the literature was incorporated in the article of Stevens,[7] in 1919. He recorded observations on twenty-two cases developing in two army camps during the war. The secondary attacks all occurred within six months of the original. Among these there were a number in whom the early diagnosis of recurrence was made by aspiration of the chest through the operative scar before definite signs of pleural effusion could be elicited by other means. He found that cases having recurrence at the site of primary operation frequently recurred again. Eggers,[8] in 1923, writing on chronic empyema, discussed recurrence as well, basing his remarks on a study of fifty-nine cases. He noted the tendency of the empyema to be localized and to perforate the chest-wall through the old operative scar. This observation was corroborated by Hedblom later in the same year. Thirty-six of his ninety patients had spontaneous perforations of the chest-wall; seventeen of them had repeated perforations. Bronchial fistulæ were found in thirty-three of the ninety recurrences. In 1932, Pallasse and Josserand[9] discussed the question of recurrences of inflammations of the lung and pleura following apparent recovery from empyema. They reported one case of recurrent empyema, but were interested primarily in the recurrence of pneumonia. They felt that recurrence of empyema would not take place if complete pleural symphysis resulted and no pockets were left behind, this observation agreeing with that made by West in 1895.

Case Report.—C. S., a forty-one-year-old man, developed left lobar pneumonia while in the army in March, 1918. A week after this signs of pleural effusion appeared, and he was aspirated at times until April 20, 1918, when a thoracotomy was done with rib resection and tube drainage. The wound was Dakinized but his temperature continued to be elevated, and he lost much weight. A second operation was later performed which apparently successfully drained the empyema cavity as improvement was immediate and progressive. Examination in August with X-ray showed complete recovery and only thickening of the pleura. There had been drainage of the empyema wound for a period of about four months. He returned to duty September 1, 1918.

During the autumn of 1918 his regiment passed through the influenza epidemic, but he himself remained perfectly well. His good health continued until the spring of 1925,

when he developed symptoms suggesting pulmonary tuberculosis. X-ray examination at that time showed infiltration of the right apex which was considered to be tuberculous in origin. There was evidence of the left eighth rib having been resected, but nothing else indicating a previous empyema. He was treated by rest at home and in six months was thought to be entirely well. He continued then in good health until February, 1928, when he was taken ill with what was supposed to be pneumonia involving the left lung. During this illness there were pain and soreness in the region of the old empyema drainage scar. Symptoms of a lung abscess developed, and after a short time he began coughing up pus, and the pain in his side disappeared. After seven weeks he was well and back at work.

About the middle of August, 1933, he had what was thought to be a severe cold, and after a few days began having pain in the region of his old drainage scar. The pain varied in intensity and responded at times to applications of heat. He continued to run a slight fever, felt under par, and the pain recurred frequently. Swelling of the region of the scar appeared, and associated tenderness and pain suggested the development of an abscess of the chest-wall. An X-ray of the chest was taken and reported as showing no evidence of osteomyelitis of the rib underlying the scar, or any change in the lung or pleura. Conservative treatment was continued, but the evidences of an abscess became so apparent that incision and drainage was decided upon. The patient began expectorating pus and coughing at frequent intervals. The fever mounted and chills occurred. Operation was performed in his doctor's office, an incision being made into the swollen area. After going to a depth of an inch no pus was encountered and the wound was packed with gauze. This was August 31. Two days later he was admitted to the Hospital of the University of Pennsylvania, after an automobile ride of two hours, appearing acutely ill. He coughed constantly, was slightly dyspnœic and expectorated rather large amounts of blood-stained, mucopurulent sputum. Physical examination showed an incised wound packed with gauze in the midst of the swollen area involving the old empyema drainage scar. There were signs in this part of the chest suggesting fluid. X-ray examination showed evidence of an old resection of the left eighth rib. Immediately under this area there was an area of increased density extending to the posterior chest-wall, and outside of this area there was lung reaction, a slight pleural collection, and possibly pleural thickening. We could not diagnose or exclude an abscess at this examination as there was no evidence of an air or fluid level. Temperature, 100°; pulse, 86; respirations, 26. Blood: hæmoglobin, 84 per cent.; leucocytes, 23,600. The diagnosis of recurrent empyema necessitatis with a bronchial fistula was evident.

Operation was performed within a few hours. When the packing was removed from the wound there was an immediate escape of thin pus. Exploration of the wound revealed an abscess cavity in the chest-wall communicating, through a smooth rounded opening in the underlying regenerated rib, with a small pleural pocket. The lung could be felt about one centimetre from the rib and the pleura could not be seen. There was no suggestion of osteomyelitis of the rib and no foreign body was found. The soft tissue wound was enlarged and packed open with vaseline gauze. Culture of the pus showed a predominance of hemolytic streptococci, but there was also a hemolytic *Staphylococcus aureus*. Following the establishment of adequate external drainage, improvement in all respects was marked. Cough and expectoration decreased progressively and within four days had stopped. The pleural cavity became obliterated by September 9, leaving only a granulating soft tissue wound which was assiduously kept packed open. He was discharged from the hospital September 10 in good general condition and with only a granulating chest-wall wound. Röntgen-ray examination September 14 revealed complete disappearance of the abnormal pleural and pulmonary findings. Following this the wound gradually healed and he regained his health within a few weeks. He has remained well since then.

TAB

Collected Cases of

CASE	C. O., male, 8 Adm. 6/11/29 Episcopal	J. McD., male, 5 Adm. 6/21/28 Episcopal	W. Y., male, 28 Adm. 10/15/23 University	H. H., male, 29 Adm. 10/19/18 University	C. S., male, 41 Adm. 9/2/33 University	I. T., male, 35 Adm. 8/21/15 University	F.D., male, 7 Adm. 10/22/25 University
Type of original empyema	Origin unknown, left	Post-pneumonic, left	Post-pneumonic, left	Post-traumatic, right	Post-pneumonic, left	Post-pneumonic, left	Post-pneumonic, left
Treatment of primary attack	Rib resection	Rib resection, tube drainage	Rib resection, tube drainage	Rib resection, tube drainage	Two operations: rib resections; tube drainage	Rib resection, tube drainage; difficulty in maintaining drainage	Intercostal thoracotomy followed by rib resections
Duration of drainage	12 wks.	7 wks.	8 wks.	20 wks.	20 wks.	7 wks.	14 wks.
Duration of free interval	4 mos.	5 wks.	10 yrs., 6mos.	4 mos.	14 yrs , 6 mos.	10 yrs.	9 mos.
Symptoms of recurrence	Cough, foul pus expectoration, pain, swelling operative scar region	Vague general symptoms, then swelling operative scar region	Severe "cold," then pleuritic pains, malaise, fever, sweats	Spontaneous reopening of old drainage wound	"Cold," pains in left chest, swelling of operative scar region, cough, fever, chills, expectoration of pus	Pain in left chest, region of operative scar, malaise, fever, slight cough	Spontaneous drainage from old wound, "cold"
Condition found at second operation	Empyema necessitatis pointing in operative scar. Bronchial fistula	Empyema necessitatis pointing in operative scar	Small empyema cavity in old area	Simple empyema cavity connecting with chest-wall wound	Empyema necessitatis pointing in operative scar. Bronchial fistula	Shallow cavity with many pockets. Pleura thick	Sinus connected with small cavity
Treatment of recurrence	Resection of regenerated rib, drainage	Incision and drainage	Rib resection, tube drainage	Rib resection, cavity packed open	Incision and drainage	Rib resection, cavity packed open	Rib resection, cavity packed open
Subsequent course	No further trouble. Seen in May, 1934	Drainage continued until rib resection 5 mos. later. Eighteen mos. later still entirely well	Uneventful convalescence. Left hospital with draining wound. No further information	Uneventful convalescence. Wound entirely healed after one month. No further follow-up	Completely well since complete healing in November, 1933	Two more recurrences at 4 and 6 mos. intervals. Seen in 1930, had been entirely well for 4 yrs. First resolved without operation. Second involved chest-wall and required 4 operations	Uneventful recovery. Seen 1 yr. later, entirely well

LE I

Recurrent Empyema

H. J., male, 19 Adm. 11/10/17 Episcopal	C. U., fem., 15 Adm. 3/16/24 Episcopal	T. McC., fem., 42 Adm. 1/21/31 University	C. E., male, 41 Adm. 4/9/31 University	R. M., male, 43 Adm. 9/2/25 University	H. B., male, 34 Adm. 6/17/23 University	A. R., fem., 26 Adm. 9/4/20 Episcopal
Post-pneumonic, left	Post-pneumonic, left	Post-pneumonic, right	Secondary to subphrenic abscess, right	Post-pneumonic, right	Post-pneumonic, left	Origin unknown, left
Rib resection, tube drainage	Rib resection, tube drainage	Thoracotomy, tube drainage	Rib resection, tube drainage	Rib resection, tube drainage	Rib resection, tube drainage	Thoracotomy
13 wks.	8 wks.	12 wks.	16 wks.	Indefinite	Several months	6 wks.
5 yrs., 7 mos.	10 mos.	19 mos.	34 mos.	30 yrs.	7 mos.	33 mos.
"Cold," pleuritic pains left side, cough	Cough, pain left side, swelling region of operative scar	Severe "cold" followed by spontaneous drainage old wound	Chills, fever, followed by swelling of operative scar	Dull pain in region of operative scar, fever	Empyema necessitatis with spontaneous opening in old operative scar	Pleuritic pains, fever, malaise, swelling operative scar region
Large empyema cavity, recurrent. No chest-wall involvement	Empyema necessitatis pointing in operative scar	Sinus tract surrounded by bone. Indefinite empyema cavity	Empyema necessitatis, well-walled-off cavity. Dense inflammatory tissue in wall	Single empyema cavity	Large cavity with thick pleura	Empyema necessitatis pointing in operative scar
Rib resection, tube drainage	(1) Incision and drainage (2) Unroofing and packing	Multiple rib resections in three stages	Rib resection, tube drainage	Rib resection	Rib resection, tube drainage	Incision and drainage
Two more recurrences after interval of 15 mos. and 1 wk. Patient lost track of after last discharge with healed chest	No further trouble. Last seen 6 mos. after last discharge	Nearly healed 2 mos. after operation. No further information	Entirely well in 6 wks. Still well after 3 yrs.	Drained 3 mos., healed for 6 mos. then developed empyema necessitatis. Treated by incision and drainage and later by unroofing. Eleven mos. later had been well 8 mos.	Left hospital with draining wound. No further information	Left hospital with draining wound. No further information

COMMENT.—Although this is only one of the series of fourteen cases to be reported in this article, it demonstrates so well the main features encountered in recurrent empyema that it is reported in detail.

In the first place, the original empyema was of great severity and the drainage prolonged. It has been pointed out by various observers that these factors favor chronicity or recurrence as the pleura becomes thickened and the chances for pocketing of a small collection of pus are enhanced.

In the second place, there was a prolonged interval of good health and no evidence of further pleural inflammation until 1928, almost ten years after the original empyema.

The supposed attack of pneumonia followed by a lung abscess which drained spontaneously through a bronchus seems very different in retrospect. In view of the course of the last illness it would appear likely that this was in reality a recurrence of the original empyema with rupture into a bronchus and adequate drainage through this channel. Had this possibility been kept in mind and an empyema found and drained, the period of illness would have been greatly shortened.

During the recent illness operative intervention was too long delayed because of unfamiliarity with the picture of recurrent empyema and because of too great dependence upon the Röntgen-ray findings. Had the region of the drainage scar been aspirated at the first signs of local inflammation in this area pus would have been found, external drainage established, and the serious illness avoided.

From January 1, 1914, to January 1, 1934, 869 cases of empyema thoracis were admitted to the surgical services of the Episcopal Hospital and the Hospital of the University of Pensylvania. In this group there were fourteen cases of recurrent empyema. They showed many variations but in each history there was definite evidence of a free interval between healing of the primary empyema and development of the recurrence. (Table 1.)

COMMENT

Type of Original Empyema and Duration of Drainage.—In the literature there has been no comment in regard to the type of empyema most apt to be followed by recurrence. There have been no observations recorded incriminating any particular microörganism. The severity of the disease and its long duration have been most frequently associated with the cases of recurrence. In this series, twelve of the fourteen cases followed pneumonia, one followed a traumatic hemothorax, and the other was associated with a subdiaphragmatic abscess occurring as a sequel to an appendiceal abscess. Complete bacteriological studies were not available in a sufficient number of the cases to be of any value in the investigation. It is especially interesting to note that none of these cases followed the influenzal pneumonias so prevalent in 1918. The duration of the initial drainage was definitely longer than in the usual cases of acute empyema, averaging more than eleven weeks for the eleven cases in

which the duration was accurately known. The shortest period was six weeks, and the longest twenty.

Free Interval.—Care was taken in the selection of this series to include only those cases in which there was reasonable evidence of an interval of apparently complete healing of the empyema cavity associated with good health. These were considered to be cases of chronic empyema with superficial healing. The duration of the free interval varied greatly; the shortest period was five weeks and the longest thirty years.

Symptoms of Recurrence.—The early symptoms of recurrence of an empyema are not distinctive. They are usually of a vague nature, and are ascribed to an acute cold. In certain patients these symptoms may persist for a long time; and when cough has been a prominent feature, some chronic pulmonary condition such as tuberculosis may be suspected. Later, pains in the same side as the previous empyema suggest pleurisy. Definite evidences of involvement of the chest-wall in the region of the drainage scar suggest the true nature of the condition. Hedblom, in The Mayo Clinic series, noted two types of onset. In one there were evidences of an acute infection, and in the other the onset was insidious. In the group reported here, the former was the more common. That the diagnosis is seldom made before the recurrent empyema has perforated the chest-wall, has been noted by others, and was true in this series. Twelve of the fourteen cases had signs of inflammation localized to the region of the original empyema drainage scar when admitted to the hospital. Ten had evidence of an empyema necessitatis. Hedblom found thirty-six instances of this condition among his ninety cases. He also found that thirty-three of his patients had bronchial fistulæ. In only two of our cases was there evidence of bronchial perforation.

Condition Found at Operation.—Conditions found at operation in these cases were not informative as to the cause of recurrence. In only one was there pocketing, while in all the others a single cavity was encountered. There were no foreign bodies, either those introduced from without or those due to sequestration of rib ends. Thickened pleura was noted in only three, but may have been present in others also, and not recorded in the operative notes. Those in which it was noted were those in which drainage of the primary empyema had persisted for seven weeks in one, and for several months in the other two. In these cases one would consider that the cavity had become sealed off superficially, and the inflammatory process become quiescent. Recurrence was then due to a reactivation of this dormant infection. Hedblom[1] and Eggers[8] in their writings suggest that this is the usual sequence, and this explanation is certainly the most obvious one. The other explanation, reinfection of the tissue made particularly vulnerable by the primary attack, is not easily supported by positive evidence. Although there may be absence of all symptoms and signs of a closed residual empyema, even failure of the Röntgen-ray to demonstrate a thickening of the pleura, there is no certainty that a small focus does not persist. The findings at operation in those patients

in which there has been reinfection of a vulnerable area should show no evidence of a chronic inflammatory process, such as a thickening of the pleura. However, in my own experience and in the experience of others, the condition of the pleura may not be evident when one is simply establishing better drainage for an empyema necessitatis. Roswell Park, in discussing Pryor's case in 1907, suggested that recurrence of pleural and pulmonary infection was analogous to recurrence of osteal and periosteal infection. All surgeons are familiar with late recurrences of bone abscesses and of osteomyelitis after apparent healing, and the parallel seems well drawn. But here also one is probably dealing with reactivation of a quiescent process.

Subsequent Course.—Stevens[7] and Hedblom[1] found a high incidence of repeated recurrences. Among thirty-six of Hedblom's cases in which a spontaneous perforation of the chest-wall occurred, seventeen had repeated spontaneous perforations. Of our fourteen cases there were three known recurrences; but as seven of our patients could not be followed, there may have been more. As the recurrence seems to be an awakening of a dormant chronic empyema, one would expect slower healing than in an acute case. This was true of two of our cases, making a total of at least five in which there was chronicity or further recurrence after the secondary operation.

Treatment.—Early recognition of the recurrent empyema will frequently save the patient many operations and reduce greatly the period of his illness. The general symptoms are not diagnostic, but when a patient who has previously had empyema presents vague symptoms referable to the chest for which no other cause can be demonstrated, the site of the original empyema should be suspected as the source. X-ray examination should be resorted to. Should this fail to give positive information, aspiration of the chest through the old operative scar should be done. In a few cases even this procedure may still fail to reveal the pus, and one is then forced to perform an exploratory thoracotomy in the region of the old scar, or wait for involvement of the chest-wall. The condition of the patient will, of course, dictate which of these methods is to be followed.

Patients admitted with an empyema necessitatis should have adequate drainage established at once. Depending on the condition of the patient nothing further may be feasible at that time, and in some instances this may suffice. In other cases more radical operations are necessary to obliterate the cavity. Several in our series required multiple interventions before this could be accomplished. Obviously those patients presenting evidences of a long-standing process need more surgery than those in which the second attack resembles an acute empyema.

Our prime object must be to reduce the possibility of recurrence. This can best be accomplished by attention to the treatment of the primary attack. Adequate drainage at the proper time, meticulous care to see that healing progresses from within outward, and hospitalization of patients until the empyema cavity has become obliterated are the cardinal factors.

CONCLUSIONS

It is seen from a review of the literature and from a study of the empyema cases admitted to the Episcopal Hospital and the Hospital of the University of Pennsylvania during a twenty-year period that recurrent empyema presents a real problem. The vague nature of the early symptoms and the lack of familiarity with the possibility of late recurrence allow many of these cases to progress to spontaneous perforation of the chest-wall, or of a bronchus, before recognition. Among these, repeated perforations and chronicity are not uncommon. Early diagnosis permitting treatment before spontaneous drainage begins will shorten the period of illness and lessen its severity. Management of the primary attack of empyema in such a manner as to insure complete healing is the best form of prophylaxis.

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SUBCLAVIAN ANEURISM

WITH REPORT OF A CASE

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The student of medical history finds a fascinating path in the references to the treatment of peripheral aneurism. The early records are shrouded in obscurity but we read of Celsus operating with the cautery, the operation of Antyllus reported in the third century and references by the ancient writers, Galen, Aetius, Rhases and others. According to Adams' commentary in Paulus Aegineta, the ancient surgeons were aware of the use of the proximal ligature but generally they opened the aneurism after ligation. Carotid and axillary aneurisms are mentioned as incurable and presumably also the subclavian.

Centuries passed, until in the eighteenth we find Anel and Hunter advocating the proximal and Brasdor and Wardrop the distal ligature. Even then the operation of Antyllus was advocated in appropriate cases. In the nineteenth century, before the Listerian era, many records exist but the mortality was very great because of secondary hæmorrhage from infection of the ligature, and ligation of the first part especially on the left side was considered as foolhardy. Even as late as 1893, John Ashhurst in his book stated that the first part of the subclavian had been tied twenty-one times and except for Halsted's (1892) case, the others had all died. In 1910 Sherill wrote that the left subclavian had been tied successfully in but three reported cases.

The chief difficulty in the case of proximal ligation aside from sepsis seems to have that of exposure of the lesion. The great experience of Dupuytren was not proof against this as shown in the case reported in 1819 when he ligated a cervical nerve instead of the artery, and no doubt this explains the uniform pessimism of the surgeons writing in the nineteenth century. Allingham in 1899 and Lediard in 1900 resected the clavicle and successfully ligated the first part. Halsted in 1902 did likewise and excised the aneurism. Better exposure and asepsis soon showed their influence by the increasing numbers of successful cases that appeared in the literature, but even as late as 1926 Kirschner stated that ligation of the first portion of the left subclavian for aneurism is a serious and difficult procedure.

In 1903 Matas offered his operation of endo-aneurismorrhaphy and in 1913 reported that he had clinical reports of 225 cases, seven of which were subclavian. Two of these were typical, involving the second and third portion. In 1910 Sherill, and in 1923 Henry, introduced methods for an approach through the posterior mediastinum.

Two contributions by Elliot were made in 1912 and 1932. In his first paper he stated that the most satisfactory treatment in aneurism of the third

part of the subclavian is ligation of the first part together with its branches with the possible exception of the vertebral. In the event of recurrence, a cure may be effected by distal ligation of the axillary close to the sac. If the aneurism should again recur, excision should be attempted after ligation of the main arteries supplying it. He states that these operations are facilitated by a preliminary resection of the clavicle and, if necessary, of a portion of the manubrium as well.

In 1932 Elliot confirmed this opinion but added that, "In the ligation of the deeper part of the subclavian a satisfactory exposure of the vessel can be secured through the posterior mediastinum."

If the aneurism involves the first portion of the subclavian, obviously nothing can be done on the left side except a distal ligation and at the same time ligation of the carotid, but not the vertebral. When the first part of the subclavian is ligated, the internal mammary and thyroid axis should also be tied. Gangrene of the limb rarely occurs, especially in spontaneous aneurism, because the collateral circulation is adequate. As Elliot states, the danger of secondary gangrene of the extremity seems to be comparatively small after either ligation or excision, in accordance with the general observation that gangrene is more common the greater the distance from the heart at which the main arterial trunk is ligated.

Resection of the median part of the clavicle gives a good exposure of the area involved and in my case I ligated the jugular and subclavian veins to collapse them and make retraction easier. Then, using the carotid artery as a guide, the junction with the subclavian was facilitated. The vagus and sympathetic nerves were easily retracted. The pleura was opened but the thoracic duct escaped injury. The transverse scapular artery was ligated. The ligation was proximal to the vertebral artery. As the original intention was to perform an excision or a Matas' endo-aneurismorrhaphy, the major branches were not ligated.

CASE REPORT.—Female, aged thirty-seven years, admitted to Doctor Stengel's Service, Hospital of the University of Pennsylvania, August 30, 1932. There is nothing in the patient's family and personal history bearing on the affection except that after one miscarriage she had three healthy children, the youngest now being nine years old. Was never ill but about ten years ago had a "sore" on the anterior aspect of the neck which lasted a week and disappeared without treatment. Five years ago she suddenly ceased menstruating. Has had a very slight leucorrhœa since.

In March, 1932, a small lump appeared behind the outer third of her left clavicle (Fig. 1) which caused pain down the arm. Pain was so severe as to require hypodermic medication. A paralysis then began in the arm, spreading down from above, becoming complete in two months. The arm feels cold. The lump has increased in size.

On admission there were noted: unequal pupils, the left being contracted and both reacting sluggishly to light but readily to accommodation; epitrochlear and inguinal adenopathy; exaggerated reflexes; paralysis with atrophy of the left upper extremity; a pulsating aneurism of the left subclavian artery; a lessened volume of pulse on the left side.

The Wassermann reaction was positive to all antigens and the Kahn test was positive. The röntgenological examination was positive for a subclavian aneurism.

The Department of Syphilology advised conservative antispecific treatment. The patient was transferred to Surgical Service B on September 7, 1932.

On September 10, 1932, under ether anæsthesia, a curved incision was made along the line of the clavicle and the skin flap dissected well above the bulging aneurism. The sternocleidomastoid, omohyoid and anterior scalene muscles, much thinned out, were divided. The clavicle was divided about one inch from the articulation but as the area was cramped the sternal section was disarticulated. The aneurism was seen to be pressing upon the carotid artery and jugular vein and fearing injury to the latter it was ligated above. The subclavain vein was separated and ligated. The anterior and inferior aspects of the sac were then freed and in doing so a small rent was made in the dome of the pleura which was sutured. The first part of the subclavian artery

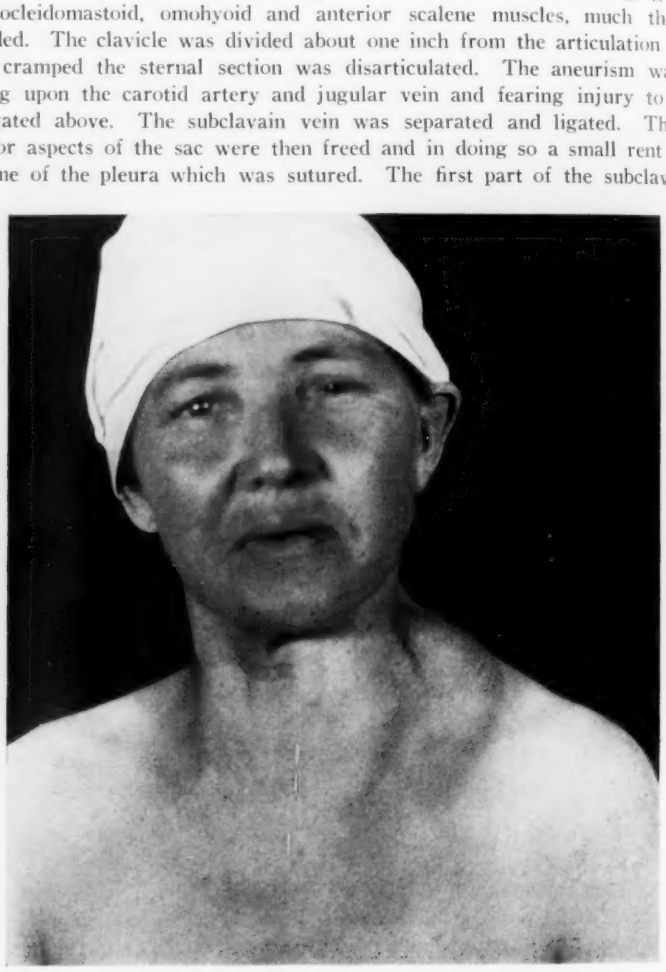

FIG. 1.—Subclavian aneurism before operation.

was then isolated from the aorta to the sac. It was about one inch long. When it was compressed the pulsation ceased in the aneurism. It was ligated twice, once with catgut and once with linen. The distal part of the third portion was ligated with catgut. A small cigarette drain was introduced and the wound closed.

Some bleeding occurred in the tissues after operation and about two weeks later the wound was opened for about one inch, the clots evacuated and the wound packed.

On October 13, 1932, under nitrous-oxide anæsthesia, an incision was made above the previous one and an attempt made to excise the aneurism. The superior and posterior aspects were so tightly adherent to the brachial plexus and other structures that the attempt was abandoned and the sac simply opened widely. All clots were wiped out; there was no bleeding. The sac was packed with iodoform gauze and the wound partly closed.

Following the ligations, as noted, the pulsations ceased and there was freedom from pain; the pulse could not be felt but the arm and hand felt warm. Calorimeter tests averaged about one degree centigrade less on the left side. There was improvement in motor activity. Antisyphilitic treatment was continued. Following the evacuation of the sac the wound closed rapidly and on discharge, October 23, 1932, was practically healed. There was no radial pulse.

It is to be regretted that specific blood tests were not followed up in this case because in July at another hospital the tests were reported as negative and one month later we found them positive. There was no history of infection nor any evidence of tertiary syphilis. After her discharge all treatment apparently was discontinued. She is Polish, lives "up-country" and too poor to report to a doctor or hospital, but in her last letter dated October 30, 1934, reports that there is no recurrence or trouble with the neck, the arm still being largely incapacitated and the hand cold at times. Evidently the overstretching of the brachial plexus has not permitted recovery because the "tumor" having completely disappeared, the pressure has been relieved. Perhaps a brachial plexus dissection may be worth while to remove the pressure of scar tissue.

THE SOCIAL AND ECONOMIC IMPLICATIONS OF THREE COMMON SOUTHERN DISEASES

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In the far South there are commonly seen three diseases which, while they do not figure largely in the death-rates of the United States, nevertheless are capable of causing, and do bring about, to an extent that is truly most demoralizing, a heavy morbidity rate, with its accompanying monetary loss, social disorganization and physical depletion. The same statement might be made concerning other diseases in the South, such as syphilis with its concomitant prevalence and disturbing effect on those who have the disease. But the problems of syphilis, and of tuberculosis, in certain respects a comparable chronic disease, are not peculiar to the South, but are ones which are widespread throughout the United States. Tuberculosis is fought very generally and most assiduously by national, state and local antituberculosis associations, health authorities and even the individuals who have the disease. Of syphilis so much cannot be said. Although probably it represents a much more afflicting disorder than does tuberculosis, yet at best antisyphilitic preventive measures are limited almost entirely to what the individual members of the medical profession can do to fight this disease.

The three diseases that are habitual in the South—malaria, pellagra and uncinariasis, are by no means confined entirely to the South, but their prevalence is much more widespread than it is in other portions of the United States. Inhabitants of the Southern States are the particular section of the population that, in large numbers, are injured by these diseases. Each one of these disorders is preventable and each one of them has little excuse for being. Pellagra, concerning the etiology of which disease there is considerable unsubstantiated discussion, might properly not be listed among the diseases usually placed in the category of "preventable," but certainly it is preventable in the sense that a proper dietary, the avoidance of alcohol to excess, and other health measures seem to preclude the development of the disease. The economic disorganization of those afflicted with this disease is well known and is very generally appreciated, but the extent of the disease and its frequency is not generally recognized.

In the past, active measures have been taken to combat the three diseases, malaria, pellagra and uncinariasis, yet as so frequently happens, after the first wave of prophylactic enthusiasm has passed by, the succeeding waves become ripples and the former general interest in a condition stimulated by a survey, a campaign, a commission or an organization, is replaced by a mere routine handling of the prevention of the disease and, sustained interest having disappeared, the diseases again become a menace. The same series of

events happens in other campaigns to eradicate noxious influences other than those produced by disease. Some years ago, during and after the War, prostitution was apparently reduced to the irreducible minimum, yet a recent bulletin of the American Social Hygiene Association shows that the incidence of prostitution is very great in many cities in this country and that with the loss of interest in the eradication of this vice problem a return to the former conditions is becoming evident. It is only by continuous, persistent, sustained hammering away at a vice, a plague, or a preventable disease that it can be kept under control. Exactly the same thing has happened with malaria control and pellagra as with prostitution. It can never be said that malaria has been under complete control in the far South, although there was considerable improvement following the measures taken to prevent the carrier of the sexual forms of the parasite, the gametocytes being a potential reservoir for the dissemination of the disease. To quote a few statistics of recent years, it might be said that in 1920 the death-rate from malaria was 3.6. In the state of Louisiana there were 586 deaths and in the state of Mississippi 683 deaths were reported for this year. In 1925 the rate had fallen to 2.1, the total deaths in the United States being 2,132 and in three particular states, Alabama, Louisiana and Mississippi, the total deaths numbered 207 in the first, 256 in the second and 426 in the third state. In 1929, the death-rate had almost doubled, there being 4,084 deaths from this disease, with a rate of 3.5, and in the three states already mentioned the total number of deaths were, respectively, 441 in Alabama, 121 in Louisiana, and 497 in Mississippi. In 1932 the fluctuating death-rate from this disease showed there were 2,567 persons who died of malaria. Figures are not available for the recent incidence of malaria nor for the death-rate, but it might be said that in 1933 the weekly morbidity reports from the state of Louisiana showed that during the fall months the reported cases of malaria were more than five times the five-year average for the same and comparable period of the year. This represents in Louisiana, and apparently elsewhere throughout the South, an enormous increase in a disease which can be prevented by appropriate therapy of the infected individual if the treatment is carried out for the period of time necessary to destroy the parasites in the host.

The disease, pellagra, represents a disorder which attacks the lowest levels of society. It is the poor man least able to afford the disorganization of sickness who is the one who develops this interesting disorder. The period of semi-invalidism, as well as actual invalidism, cannot be accurately estimated. Undoubtedly the individual sick with pellagra will have weeks and sometimes months of physical maladjustment so that even though he is able to do a certain amount of work, his efficiency is very considerably and materially lowered, while of course during the acute phases of the disease, he is virtually an economic cripple. Pellagra is essentially, in Louisiana at least, a disease of the countryside. Were the country man to raise chickens to get eggs, breed cows to get fresh milk and pigs to get fresh meat and grow a vegetable garden to secure fresh vegetables, the disease would become a rarity; but apparently

a vicious cycle is established in the life of the pellagrin. It is not the inherent laziness of the individual that makes him do away with the trouble and bother that keeping and maintaining live animals on the farm entails; rather it is the difficulty that a sickly man has in doing the chores that the farmer has to do who is keeping livestock, which prevents him from raising his own fresh foodstuffs.

The Thompson-McFadden Pellagra Commission twenty years ago studied intensively the problem of pellagra in several of the southern Atlantic states. Their findings focused attention on a disease which had only been recognized generally less than a decade previously. Some of the fact-finding studies of this commission apparently do not hold true nowadays. One of their observations was that pellagra is seen more frequently in built-up than in rural communities. Thus, in a cotton mill village the rate of prevalence was shown to be 184 per 10,000 against sixteen per 10,000 in rural sections. Parenthetically, it might be observed that these figures and similar figures have helped to sustain the idea that pellagra is primarily an infection. Cases observed in Louisiana, however, do not conform to these figures. Here it is found that pellagra is very generally a disease of the rural divisions and not of the suburban or urban portions of the state.

Another interesting observation from the mass of material that was collected and compiled by this commission has to do with the fact that pellagra is a disease which is very generally not seen by the physician. The report comments upon the fact that probably only 10 or 15 per cent. of pellagrins see the doctor or consult him for their condition. The remaining 85 or 90 per cent. are substandard physically, well below par in health, but because of financial inability to meet the doctor's bills do not consult a physician unless they are severely ill. These figures at the present time may be discounted in part, but undoubtedly they represent a truth which cannot be definitely established, nor denied.

The extent of pellagra cannot be grasped by one who is not familiar with statistics. When, as happened in 1929, the disease takes a toll of nearly 7,000 lives, then only can it be appreciated that here is a disease which is among the higher individual disease entities in its death-rate and which according to the figures of the Thompson-McFadden Pellagra Commission must have a morbidity rate immeasurably higher. If conservatively it is estimated that one out of every thirty pellagrins dies, then there must be 150,000 or 200,000 cases of the disease occurring largely in one relatively sparsely populated portion of the country, a perfectly enormous tribute to sickness to be paid by the populace of a section of the country.

The death-rate of pellagra varies considerably from year to year. Again to take sample years and states, we find that in 1920 the rate was 2.7 and that in the two states of Louisiana and Mississippi, Alabama not reporting at that time, there were 203 deaths in the first and 558 in the latter state. In 1925 the rate was 3.2 as a result of 3,344 deaths, 532 of which occurred in Louisiana, 570 in Mississippi and 413 in Alabama. In 1929 the rate increased

to 5.8; in 1930 the rate was slightly smaller, there being 6,332 deaths; in 1931, 5,090 deaths; in 1932 there were 3,694 fatal cases. (Mortality Statistics of the Department of Commerce, Bureau of Census, September 28, 1933.)

Pellagra is a disease which attacks both races, but the banner year of 1929, as do other years when the disease is less prevalent, shows most lucidly that the colored death-rate is materially higher than is the white. Thus in Alabama, whereas there were 239 white deaths, there were 437 colored; in Louisiana fifty white people died of the disease and 235 Negroes. In Mississippi the white deaths numbered 108, whereas in the Negroes it was 646. Statistical evidence also shows that these deaths occurred in the greatest number in the third and fourth decades of life, at the time of the greatest economic fruitfulness of the individual.

Uncinariasis is a condition which at one time, but no longer, was responsible for ill health in a very large and wide cross-section of the Southern population. This disease is presented in this discussion largely to contrast what can be done with intelligent effort in the prevention of a disease for which there exists an efficient cure and which can be prevented by appropriate sanitary measures. The International Health Board, among other public and eleemosynary organizations, has done a tremendous amount of beneficial work in ridding the South of this disease. They have taught and they have practised. As a consequence of their sustained efforts, uncinariasis is a relatively uncommon disorder, if we speak of the disease as one producing clinical expressions. It is true that hookworm infestations of a slight degree are relatively common, but on the other hand, the disabling anæmias that at one time were so prevalent in the hookworm-infested population have largely disappeared. At Charity Hospital only very occasionally is a child seen with a high-grade infestation and with a severe anæmia, or, what is especially interesting, sporadic cases are observed among pregnant women who have an accompanying very high-grade anæmia without a corresponding high worm count, illustrating the inability of the bone marrow of some pregnant women to respond to any abnormal demands.

To epitomize and summarize what has already been written, it should be accentuated that there are two diseases in the South, malaria and pellagra, which are sources of tremendous economic loss and social disruption to the peoples of this section of the United States. Both of these diseases are preventable to much more than a limited extent. Malaria control, whereby the anopheles mosquito is eradicated, is utterly beyond the realms of financial possibility, but a modified control could be maintained by proper therapy. Pellagra, from the information at hand, is a disease which likewise could be controlled in part by the education of the communities in which the disease is prevalent. Hookworm infestation is reasonably well controlled. The efforts that have been made in the past to eradicate these diseases should be maintained and added force should be given to curb these extraordinarily common diseases. This best can be done through enlightened public opinion and education, an effort which should be sustained and maintained not for a period of a few brief years but continuously.

SELECTIVE THORACOPLASTY IN THE TREATMENT OF PULMONARY TUBERCULOSIS

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The attitude toward thoracoplasty procedures in the treatment of pulmonary tuberculosis is changing. The selection of cases, their management, the sequence and extent of rib removal, the spacing of stage operations, and the combination of various forms of collapse therapy are now viewed differently than was the case a few years ago. More attention is given to the obliteration of cavities, to a more complete collapse of the involved lung, and to a greater conservation of uninvolved lung. Mortality rates have been lowered and late results have been improved. These favorable changes have justified a wider application of the thoracoplasty operation.

It is the purpose of this paper to discuss the value of upper limited or selective thoracoplasty in the collapse therapy program. Emphasis is placed upon the effectiveness of the collapse, the conservation of uninvolved basal portions of the lung, the availability of the method in bilateral disease, the importance of a long interval between stages, and factors which make a low operative mortality possible.

When the term thoracoplasty is mentioned, there is generally visualized an ultraradical procedure in which the entire hemithorax has been dropped down in a state of irreversible collapse. The requirements of the standardized thoracoplasty have included: First, that the lower ribs be resected in the beginning so that sudden emptying of apical cavities with a subsequent bronchiogenic spread could not take place; next, that the second-stage operation follows shortly upon the first, because a delay of over two weeks resulted in a stiffening of an incompletely collapsed lower thoracic cage due to periosteal regeneration; and finally, that collapse would not be adequate and complete unless a portion of all the ribs including the first (and excepting the twelfth) be removed in order to permit the entire costal cage to drop downwards and medially (Fig. 1).

Undoubtedly, the feeling that a complete thoracoplasty was necessary in all cases was partially due to the practice of doing the lower-stage operation first. Apical cavitation necessitated in practically all instances a resection of the upper ribs. Therefore, when lower ribs had been first resected, one was committed to carry out a complete collapse of the hemithorax by following with a second-stage upper thoracoplasty. There is another explanation for the feeling that once a thoracoplasty is decided upon, a complete collapse should be done in the majority of cases. This applies when the stages of the operation are reversed, that is, when the upper ribs are resected first. In

such a plan for thoracoplasty, the procedure is usually performed as follows: an upper-stage resection of two, three, or four ribs is followed by a second upper-stage posterior resection, then an anterolateral, or parasternal operation, and finally, the lower stage, each spaced ten to fourteen days apart.

Considerable emphasis has been placed upon the short interval between operations until the complete collapse has been accomplished. Such a short spacing of stage operations has made it impossible to evaluate the improvement or the extent of cavity obliteration obtained by the upper stages of the procedure. Lung detail below the area collapsed in recent post-operative films is obscured by œdema (lung reaction near the site of the operative procedure). It is difficult and almost impossible to estimate within a ten-day period after

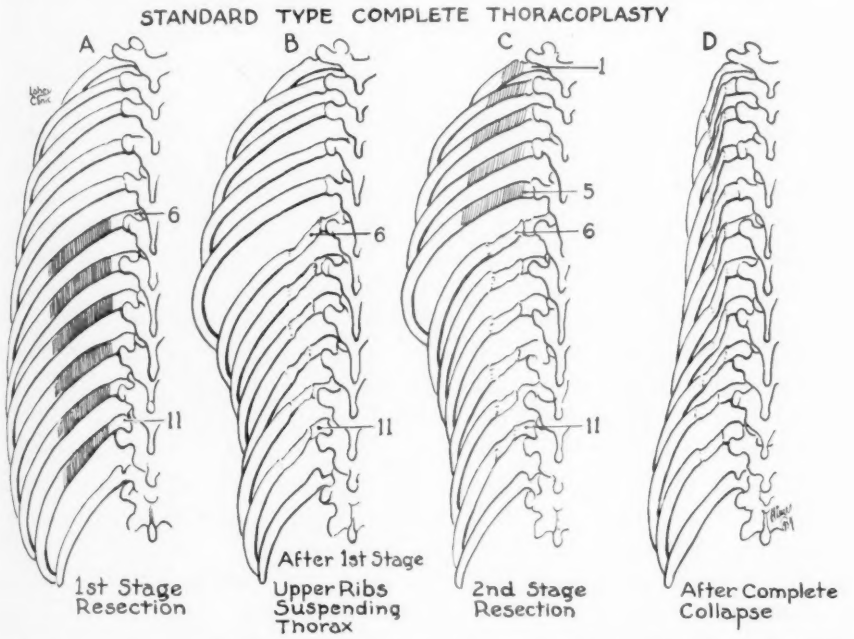

FIG. 1.—Diagrams illustrating the plan and extent of the standard type of paravertebral thoracoplasty. (A) The plan of the first-stage operation, the resection of posterior segments of ribs six to eleven inclusive. (B) The result of the low, first-stage thoracoplasty showing the position of the remaining rib segments. Note the suspending effect of the upper ribs. (C) The plan of the second stage, a paravertebral resection of ribs one to five. When the operations are reversed and the upper resection is done first, the final result is the same. (D) Final result when resection of eleven ribs has been carried out. Entire hemithorax has been thrown downwards and medially. Generalized relaxation of lung results.

a thoracoplasty operation, the amount of diseased lung adequately collapsed or the amount of healthy lung that need not be sacrificed by more operative work. Also, a period of two or three weeks is wholly inadequate in which to study the effects of whatever collapse has been accomplished by a single-stage operation upon the clinical aspects of the case. Therefore, if one operation must follow shortly upon another, and it is then impossible to evaluate the amount of collapse secured by each operation, it has naturally followed that the error be made on the safe side of completeness by dropping down the entire chest.

The point of view that in order to collapse satisfactorily any part of the lung, the entire hemithorax must be let down, resulted in a limitation of the operation to three groups of cases: first, to the stationary chronic fibroid type of extensive unilateral tuberculosis; secondly, to the extensive progressive unilateral, yet good risk case, when all other measures had failed; and finally, to unilateral cases in which complications had interrupted the continued use of pneumothorax. Further limitations were placed upon the operation because moderate involvement or a cavitation of the upper third of the lung hardly justified a complete collapse of the entire lung on that side. Bilateral cases in which there was more than a minimal involvement of the better lung could not even be considered.

Reports on the results of thoracoplasty operations indicate that the majority of surgeons do the total collapse operation as the standard procedure. In Alexander's[1] summary of cases up to 1925, partial operations were by far in the minority. Sauerbuch[2] prefers to do the complete operation and to do it in one stage. Huber and Waitz[3] report from the clinic of Professor Ranzi a ratio of complete operations of sixty-six to fourteen of partial operations. Denk[4] did 168 complete thoracoplasties out of 222. In this country one receives the impression from end-result studies that the complete collapse procedure has been used in the great majority of cases. Barnes,[5] Carter,[6] Coryllos,[7] and Weiner and Fishberg[8] have presented thoracoplasty results in which the complete operation apparently was the only type done. In a recent description of the technic of thoracoplasty by Carter[10] the impression was given that a multiple-stage complete operation was the usual type performed. Alexander[11] has recently advocated the resection of long rib segments for large apical cavities, beginning the resection from above. Bruns and Casper[9] have described a modified upper multi-stage thoracoplasty in which gauze packing is inserted in the collapsed area for a time and then removed. Johns and Cole[12] and O'Brien [13] have reported experiences with upper limited thoracoplasty. Johns and Cole did not state the proportion of cases in which a limited thoracoplasty was sufficient. In O'Brien's report of last year, presumably the greater number of thoracoplasties were upper limited operations.

Applicability of Partial Thoracoplasty Operation.—In the past two years, 120 thoracoplasty operations for pulmonary tuberculosis have been performed upon seventy-three patients by the Department of Thoracic Surgery of the Lahey Clinic. (Table I.) In fifty-two of the seventy-three patients treated, the involvement was limited to the upper half of the chest. In all of this group of patients, collapse activities have been confined to the upper portion of the hemithorax. In other words, these patients have received a partial thoracoplasty only. Twenty-one of the seventy-three had complete involvement of the lung on one side. However, it has been necessary to do a resection of ten or eleven ribs in only thirteen of this number, a proportion of 18 per cent. of the total number treated. In five of the patients with a complete unilateral involvement, a removal of the upper eight ribs sufficed inasmuch as a marked diaphragmatic elevation incident to phrenic nerve paralysis ob-

viated the resection of the lower ribs. Some of these cases are too recent to pass final judgment on. However, a freedom of all symptoms and a negative sputum at the present time, together with the X-ray examination which fails to show the presence of open cavities, seem to us to be sufficient reason to defer further surgical work. In the remaining three patients with apparently complete unilateral involvement, a resection of the upper seven ribs has so far seemed to be sufficient, even though a paralysis of the diaphragm has not been produced.

Why should a limited or selective thoracoplasty be the operation of choice in such a high percentage of the present series? The answer is that a high percentage of cases do not have complete unilateral involvement and in such

TABLE I

Summary Thoracoplasty Cases

September, 1932–February, 1934

Total No. Patients Operated on	73
Total No. Stages	120
Operative Deaths	3
Sanatorium Deaths	2
Partial Thoracoplasty	60
Complete Thoracoplasty	13
Incomplete Stages	27
Cases Too Recent to Follow	7
Collapse Therapy Finished	35
Cavities Closed by X-ray	34
Negative Sputum	30
Unimproved	2
Improved	8
Quiescent	7
Apparently Arrested	18
Discharged Sanatorium	15

Summary of cases treated since Department of Thoracic Surgery was organized in the Lahey Clinic. This is a cross-sectional view of the status of the patients operated on up to February 1, 1934. Note high incidence of partial thoracoplasty. Undoubtedly, a few of the uncompleted cases will eventually require complete thoracoplasty.

cases the operation should be limited to the areas involved. Careful planning in regard to the number and the extent of ribs removed has provided a way to conserve basal portions of the lung as well as to more satisfactorily close in cavities above. There are two objectives behind all types of collapse therapy: one is to provide rest to the lung, the other to reduce the lung volume. By far, the most important of the two objectives is the reduction in lung size. A permanent reduction in the size of the lung is desired for the following reason: The disease process in the lung has destroyed part of its substance. If nature has responded well, fibrous tissue is formed in the vicinity of the disease, and healing takes place through the efforts of the fibrous tissue to contract down and close in the area created by the tuberculous process. As a result of this fibrosing process on the involved side, there takes

place a compensatory expansion of remaining lung tissue, a shift of the mediastinum, a diaphragmatic elevation, and a narrowing of the spaces between the ribs. If these adjustments can occur to a sufficient degree, cavities become obliterated. The patient is then left with a fibrotic lung which is smaller than the normal lung but adequately filling the hemithorax because the size of the hemithorax has been reduced sufficiently to meet the requirements of the size of the new fibrotic lung. Should the alteration of surrounding structures fail to reduce the size of the hemithorax sufficiently, cavitation results. In other words, pulmonary cavitation represents the difference between the thoracic cage volume and lung volume. A thoracoplasty operation, then, should diminish the size of the hemithorax to the extent that its volume equals the volume of the remaining healthy lung.

The Plan of the Operation.—In planning a thoracoplasty operation, resection of ribs should be so carried out that, first, cavities are obliterated; secondly, that normal lung be conserved and finally, the general size and contour of the hemithorax be reduced to that of the normal or healed lung on that side, allowances being made for a diminution in elasticity on the involved side. The Röntgen-ray film is used as a guide to determine the extent of lung collapse necessary. In addition to the size and location of cavities, the amount of fibrosis in the underlying lung must be considered. If cavities in the upper third are unattended by fibrosis in the lung tissue below, and if the area of the lung below is not greatly reduced in volume as indicated by mediastinal and diaphragmatic displacement, the actual diminution in the size of the thoracic cage will not have to be much more than enough to include the area of cavitation. In such a case, an imaginary line can be drawn horizontally below the lowest border of the lowest cavity and the resection planned to include the area above that point. In Fig. 2 is illustrated the plan of resection where the entire first and second ribs, the posterior half of the third and the posterior third of the fourth are found above the line of resection.

When extensive fibrosis is present throughout the lung on the involved side a greater total reduction in the size of the thoracic cage must be made. In order to provide the necessary relaxation of the fibrotic lung, the resection should go below the area of cavitation. A comparison of the two lung fields in the Röntgen plate will give a fair estimation of the extent of the collapse necessary. If the total area of involved lung is only one-half of the area of the better lung, the thoracic cage should be reduced that much and a resection of seven or eight ribs planned. The length of ribs resected should be governed by the location of underlying cavities. If the affected lung area is only one-third of the better lung, a more extensive thoracoplasty should be planned. Re-study of each case, however, between stages, gives the most accurate estimation of additional collapse needed and insures greatest conservation of lung at the base.

In addition to varying the length and number of ribs for resection in relation to the extent of the disease, it is also essential to vary the extent of resection in regard to the ability of the patient to withstand the shock of

the operation. In most cases, it is safe to remove the equivalent of the lengths of the upper three ribs at one operation. If the resection of posterior segments of more than three ribs is desired, including as many as the upper six, we then prefer to remove only the posterior half of the upper three and shorter posterior segments of the next three. We feel it is unwise to remove the anterior portions of the second, third and fourth ribs at the time of the posterior upper thoracoplasty. Too large an area in the unprotected upper anterior chest is rendered flaccid. Paradoxical movement takes place in a large area, complicates convalescence and endangers the patient. For that

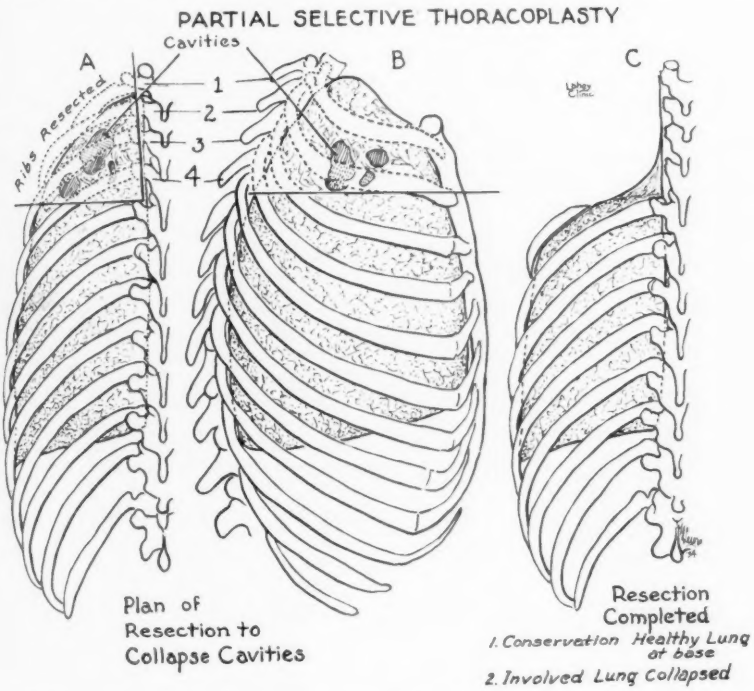

FIG. 2.—Diagrams illustrating the plan of partial or selective thoracoplasty when cavitation is limited to the upper third. (A) and (B) A horizontal line is drawn below the area of involvement and the resection planned to include portions of the ribs above that line. In this particular instance, all of the first two with the posterior portion of the third and fourth should be removed. If the area included in the plan of resection be more than the patient can stand at one operation, a multi-stage procedure must be done. (C) Diagrammatic representation of result of selective collapse. The apex of the thorax is virtually cut off at right angles to the vertebra. The collapse is complete within itself, as far as it goes.

reason we prefer to leave one inch of the second rib, and two inches of the third next to the sternum to protect this area. A parasternal or anterolateral resection of these stumps can be done later if necessary.

In bad risk cases and in the event of bilateral cavitation, the resection should never include more than two or three ribs. In cases where the pleura is thin and little fibrosis is evident, shorter posterior segments are resected. The anterior upper chest-wall is not then rendered flaccid by a long anterior segment removal at the time of the posterior operation. When stabilization

has occurred because of considerable fibrosis, longer rib segments should be taken out. Fig. 2 diagrammatically illustrates the manner in which the limited upper thoracoplasty provides a complete limited collapse in the area of resection.

One of the principle arguments for a complete rib removal at the apex of the thoracic cage at the time of the first operation is the completeness of the collapse obtained in that area. The costopleural membrane drops down so well that practically none of the area treated is suspended by ribs outside of that field. The apex of the lung drops down, the collapse is complete as far as it goes, and there is no necessity to be hasty about the second operation.

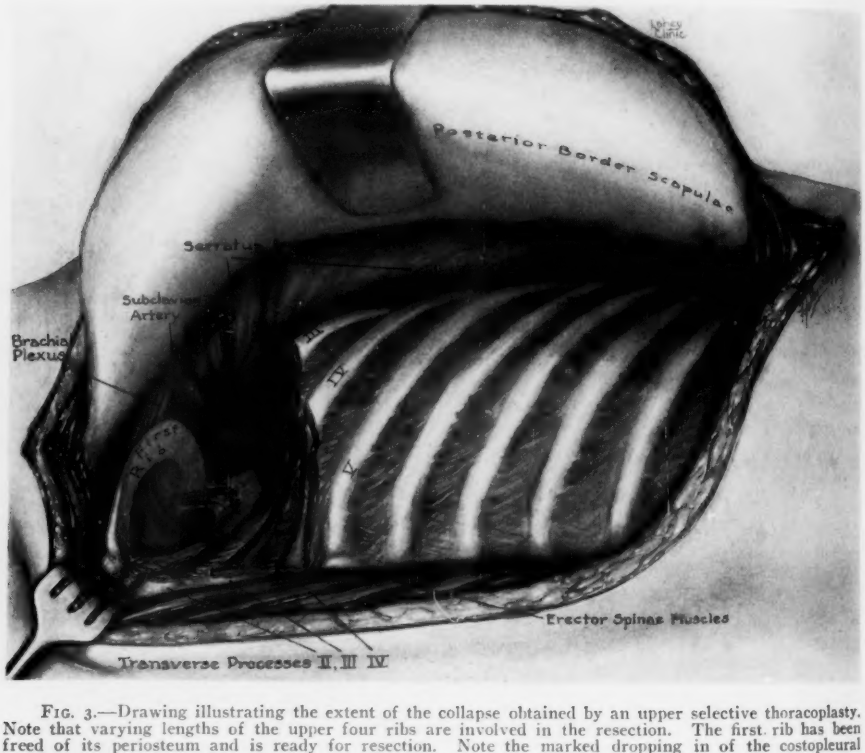

FIG. 3.—Drawing illustrating the extent of the collapse obtained by an upper selective thoracoplasty. Note that varying lengths of the upper four ribs are involved in the resection. The first rib has been freed of its periosteum and is ready for resection. Note the marked dropping in of the costopleural membrane and intercostal tissue. Note the excellent exposure of the first rib. The transverse processes are sectioned close to the vertebra.

A final satisfactory collapse does not depend, then, upon a short interval between stages. We have not used a chemical to destroy the periosteum of the upper ribs, feeling that it is advisable to ultimately have a rigid thoracic cage. Fig. 3 is a drawing of an upper thoracoplasty showing the extent of the collapse obtained by the first stage of the thoracoplasty. The upper thorax is virtually collapsed at right angles to the bodies of the vertebræ. Because of the sloping downward of the ribs as they arch anteriorly, it is necessary to resect the posterior portions of more ribs than are resected anteriorly. A resection planned at right angles to the vertebral bodies provides the most

FIG. 4.—Röntgenograms made before and after resection of three ribs to close apical cavity. Patient N. H., State Sanatorium. Referred by Dr. R. M. Deming. Aged twenty-nine. Duration of disease two years. Pneumothorax unsuccessful. Temporary phrenic paralysis one year previously had no effect upon size of cavity. Cavity closed by limited thoracoplasty and patient discharged from sanatorium eleven months later as apparently arrested case. (This was one of our earlier cases and the transverse processes were not resected as close to the vertebral bodies as is advisable.)

complete collapse in that limited area. After such a procedure is carried out, if the underlying cavity is not collapsed, it will descend and come to lie under the fourth or fifth rib and will be completely collapsed at the time of the second operation. In Fig. 4 is shown the pre-operative and post-operative röntgenograms of a patient who had a limited upper thoracoplasty for a 3.5 centimetre right apical cavity. Pneumothorax had been unsuccessful. A temporary phrenic nerve paralysis resulted in an adequate rise of the diaphragm but, after one year, no change in the size of the cavity could be seen. A resection of the upper three ribs dropped down the apex of the thoracic cage sufficiently and relaxed the fibrous tissue enough to effect a cavity closure.

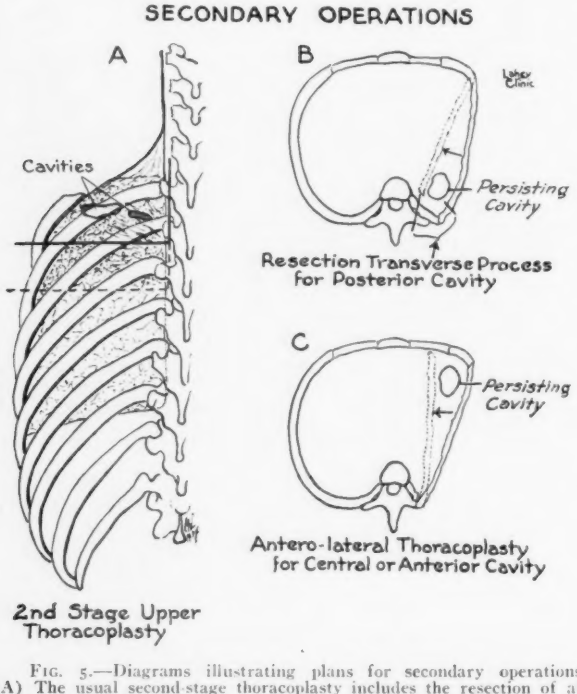

FIG. 5.—Diagrams illustrating plans for secondary operations. (A) The usual second-stage thoracoplasty includes the resection of all of the posterior portions of additional ribs in most instances, the fourth, fifth and sixth and often the seventh ribs. It is well to go beyond the area of cavitation so that the remaining hemithorax will not put too great a tension on the remaining underlying non-cavitated lung. The greater the fibrosis, the more liberal the resection. (B) Diagram showing position of persisting posterior cavity protected by the transverse process and vertebral body. This situation calls for a resection of the stumps of the transverse process and a freeing of the lateral thoracic wall so that it will move medially and obliterate the posterior gutter. (C) Position of cavity protected by anterior stumps. In this situation, a parasternal or anterolateral operation should be done.

As Alexander[14] pointed out, it is necessary to resect the transverse processes as well as the entire posterior angle of the rib. These stumps support the lateral reformed chest-wall, holding it out beyond the vertebral bodies to such an extent that a posterior cavity will remain open. A cavity that has been posteriorly displaced by the collapse will be protected and fail to close in (Fig. 5). We have not found it necessary to resect the transverse process of the first rib and it is also unnecessary to cut the transverse process of the second rib as short as should be done with the transverse processes below that point. The apex drops down so that the upper two transverse processes never interfere with the closing of cavities. This is quite a valuable point inasmuch as it conserves time in the resection of the upper two ribs and also has the advantage of not weakening the lateral support of the vertebral column in this region.

Interval of Time between Stages.—One of the most important points in the successful management of patients through a complete series of thoracoplasty procedures, is to space the various stage operations at the most oppor-

tune time. A majority of thoracic surgeons advise that the second-stage procedure be carried out within nine to fourteen days following the first operation. There are two important objections to this plan, both of which argue strongly for a longer interval between stages. In the first place, many tuberculous subjects are not strong enough to safely go through a second or third major surgical operation within ten days of the preceding major operation. Any patient too sick to stand a seven- or eight-rib removal in one operation is too sick to undergo a seven- or eight-rib resection within the following ten-day period. During this time, the setback incurred by the first operation has not been compensated for. Furthermore, there has not been sufficient time for the patient to receive the benefits of the collapse provided by the first procedure. Four to six weeks must elapse before the effects of collapse of a certain portion of the diseased area reflects itself in diminished cough, a reduced amount of expectoration, and in an improvement in the general condition resulting from a lessened toxicity of the disease itself. The principle of the staging of operations holds good in thoracoplasty to the same extent that it does in any field of surgery. If a stage operation partially relieves the patient of his trouble, its purpose is defeated unless a period is given during which time the benefits from operation can accrue.

The second important reason for delaying the various stages applies in all cases where total involvement of the lung has not taken place. The full value of the first-stage resection is not evident until four to six weeks have elapsed. Opportunity should be permitted for estimation of clinical improvement, presence or absence of organisms in the sputum, weight, appetite, and all factors relative to activity of the process. Röntgen-ray study should then be made to determine the effectiveness of the collapse of diseased lung and a study made of the condition of the uncollapsed lung. Short of six weeks, the X-ray film is clouded as a result of the lung reaction incident to the operative procedure. The status of the lung base is difficult to work out. Accuracy in this regard is important in order to decide upon the necessity for, or the extent of, a second-stage operation. It has been our policy to have patients leave the general surgical hospital in Boston and return to their respective sanatoria for this interval between stages.

Additional Stage Operations.—When the patient comes up for the second stage of the operation, the type of procedure is varied. The object of the secondary operation is the same as it is in the primary one, that is, to collapse involved lung and conserve uninvolved lung. For a cavity below the area of resection, a second series of ribs is resected posteriorly, including the transverse processes. In Fig. 5, there is diagrammatically represented the plan of resection for cavities below the area previously collapsed. Unless six or seven ribs have already been removed at the first operation, the second procedure usually consists in the resection of additional ribs. In the event, however, that the collapse went beyond the area of cavitation and the röntgenograms show the cavity in the area previously resected, there are two possibilities for consideration, that the transverse processes are suspending a

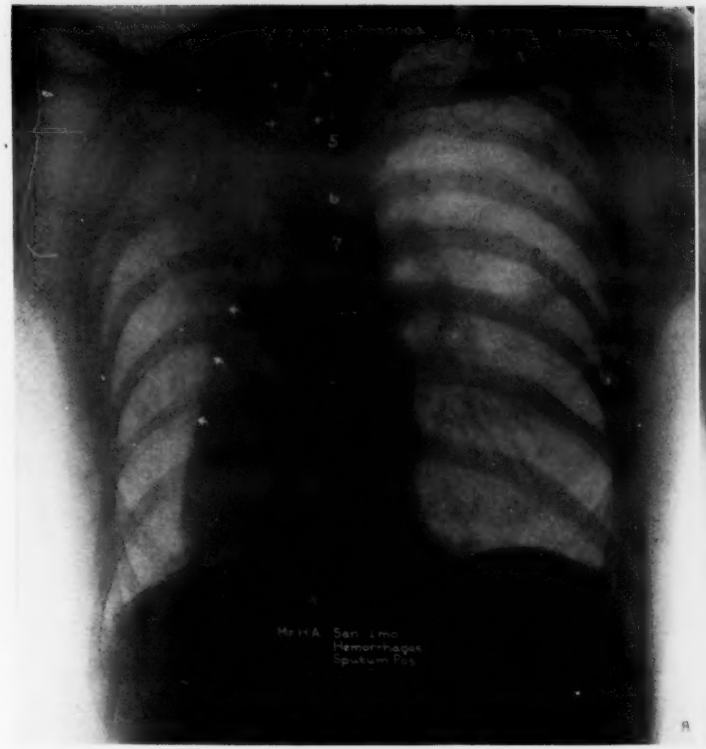

FIG. 6.—Röntgenograms of a man, aged thirty-six, who had extensive fibroid tuberculosis of the upper half of the left lung. Referred by Dr. G. H. Smith, of the Bristol County Sanatorium. Röntgenogram on admission to sanatorium as hæmorrhage case. Note tracheal deviation toward affected side, narrowed inter-rib space on left and narrowing of hemithorax on that side. Patient operated on one month after admission to sanatorium, thoracoplasty being selected as procedure of choice. Bed rest controlled hæmorrhages. The lung would obviously not re-expand after pneumothorax so it was not attempted. A phrenic nerve paralysis would be obviously ineffective and would diminish function of basal portions of lung. A permanent collapse of the involved lung by selective thoracoplasty was therefore the logical collapse measure to recommend.

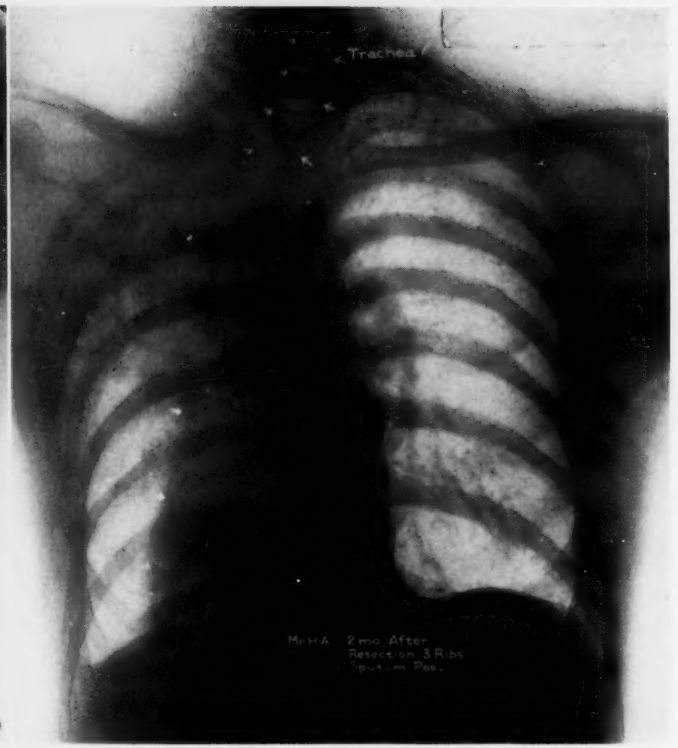

FIG. 7.—Röntgenogram in patient, H. A. (same as Fig. 6) after first-stage upper selective thoracoplasty. The upper three ribs have been resected. Note the diminished area of involved lung. The pull on the upper mediastinum has been relieved partially as indicated by the return of the trachea toward the mid-line. Marked clinical improvement. Sputum amount reduced by 75 per cent.

posterior cavity or that an anterior cavity is kept open by the anterior stumps (Figs. 5B and C). A resection of these remaining processes with or without additional ribs below may be necessary. This type of secondary operation has been required in three of our series of seventy-three patients. Should the anterior portions of the upper ribs be holding out the upper anterior portion of the collapsed area, a parasternal or anterolateral resection of these stumps should be done. In four of the series of partial thoracoplasties, this procedure has been carried out.

Experiences with a patient referred by Dr. G. H. Smith of the Bristol County Sanatorium illustrates what may be accomplished by planning a thoracoplasty procedure

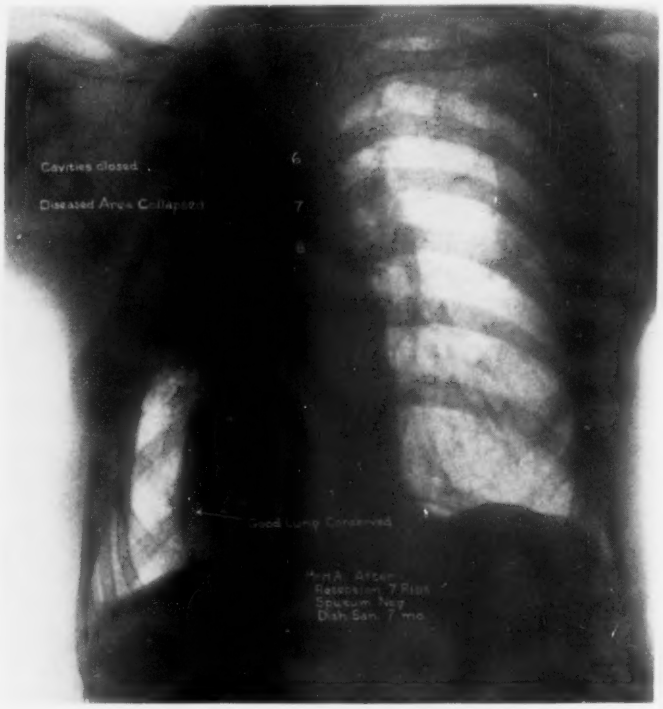

FIG. 8.—Röntgenogram in patient, H. A. (same as Figs. 6 and 7) after second-stage selective thoracoplasty. The major portion of the upper seven ribs has been removed. Note completeness of collapse in upper half of thorax. Compare amount of lung base conserved with area of uninvolved lung as indicated in pre-operative X-ray (Fig. 6). Note return of heart and mediastinum to the normal position. This patient entered the sanatorium as a far advanced case and was able to leave the sanatorium seven months later as an apparently arrested case.

to provide the necessary collapse and conserve the base of the lung, early in the patient's sanatorium history. Mr. H. A., aged thirty-six, was admitted to the sanatorium as a hæmorrhage case and found to have an extensive fibroid type of tuberculosis limited to the upper half of the left lung (Fig. 6). Bed rest alone controlled the hæmorrhages. Thoracoplasty was proposed at once for the following reasons: 1. The disease was limited to an area that could be collapsed in a permanent way and at the same time not sacrifice the uninvolved lung at the base. 2. The patient's general condition indicated that he was a good surgical risk. 3. Other methods of collapse therapy would be

inadequate and fail. He would be in constant danger of an extension of the process. Prolonged invalidism in the sanatorium was a certainty.

Pneumothorax was not attempted. Should the lung be collapsed by that method, a re-expansion would obviously be impossible. A phrenic nerve paralysis would be ineffective in collapsing the extensive apical involvement and would reduce the patient's ventilating ability in the base of the lung on that side. Therefore, if thoracoplasty is the ultimate procedure which will arrest the process in this case, it should be used early in the course of treatment. The patient was advised to have a thoracoplasty. He accepted the advice and one month after his admission to the sanatorium, he was transferred to the New England Deaconess Hospital. A first-stage upper thoracoplasty (three ribs) was done and two weeks later he was transferred back to the sanatorium. After a period of six weeks, the case was reviewed, the sputum had continued to be positive and the X-rays showed persistent cavities below the area of collapse. The patient then returned to Boston and four more ribs were removed (Figs. 7 and 8). All sputum examinations after the second-stage operation were negative. The patient stopped coughing and there was no expectoration. He was discharged from the sanatorium seven months after his admission as an apparently arrested case.

Thoracoplasty for Bilateral Involvement.—The use of selective surgical collapse has broadened the indications for this type of thoracoplasty. Many cases of bilateral involvement may be benefited by a collapse of the most involved apex or a limited bilateral upper thoracoplasty. In the present series, eight patients had active bilateral disease with bilateral cavitation. There has been improvement in both the operated and in the contralateral lung in all but one case. The one exception was due to an operative death eight days

TABLE II

Present Status Thoracoplasty Patients

September, 1932–February, 1934

								Summary Partial Thoracoplasty	Complete Thoracoplasty
Number Ribs Resected..	2	3	4	5	6	7	8		9–10–11
Collapse Work Apparently Finished.....		3	5	5	6	7	1	27	8
Cavities Closed by X-ray		3	5	5	6	7	1	27	7
Sputum Negative.....		3	2	5	5	7		22	8
Unimproved.....									2
Improved.....			3		1	1	1	6	2
Quiescent.....		1	2	1	1	2		7	
Apparently Arrested....		2		4	4	4		14	4
Discharged.....		2		4	4	1		11	4
Stages Incomplete.....	2	7	4	5	1	3	1	23	4
Too Recent to Classify ..		1	1		4			6	1

Cases summarized to show the number of ribs removed and the present status of the patients. The numerals at the top of the table indicate the number of ribs resected. The numerals in the table proper represent the number of patients so treated. Note that the number of improved and arrested cases is just as high with partial thoracoplasty as with complete thoracoplasty. Note that the resection of the upper five or six ribs was sufficient to arrest the disease in a large percentage of the patients in which this limited number of ribs was resected.

after operation. (Table II.) In Fig. 9 is diagrammatically represented the explanation for contralateral improvement in bilateral disease. If an upper thoracoplasty is done on the side showing the most fibrosis or on the side showing the greatest tension, sufficient relaxation of the upper mediastinum is produced to effect a cavity closure in the opposite apex. A deviation of the trachea toward the most involved side after operation will be found in the mid-line or even curved in the opposite direction. This suggests a marked relaxation of the tension in the contralateral lung.

In four cases, a bilateral upper thoracoplasty was planned but so far improvement of the better lung has been so gratifying that a bilateral operation has not been required. In Figs. 10, 11, and 12 are shown röntgenograms of an active bilateral case for whom a bilateral upper thoracoplasty was

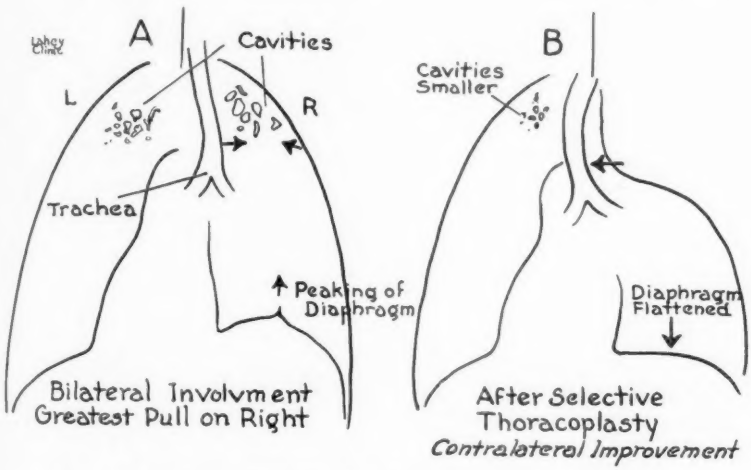

FIG. 9.—Diagrams illustrating the effect of upper limited thoracoplasty in bilateral cavitation. The resection is carried out on the side where there is the most extensive tension of fibrous tissue as indicated by tracheal deviation. (A) Shows evidences of fibrous pull in right lung. Note position of trachea, relatively decreased lung area and peaking of diaphragm. (B) After resection of upper ribs on the most involved side, there is a deviation of the trachea towards the opposite side. This tends to improve the contralateral lung by permitting fibrous tissue to close in upon the cavity.

planned. In this case, a limited upper thoracoplasty on the most involved side has proven to be sufficient.

CASE REPORT.—Mrs. V. R., aged twenty-eight, had been sick two years. During eighteen months of this time, she had been confined to the Bristol County Hospital. Bilateral apical cavitation was found with extensive involvement of the upper third of the left lung (Fig. 10). Pneumothorax was not successful. There was a temporary improvement after admission with a later extension of the process on both sides. A bilateral upper thoracoplasty was decided upon. The upper left thoracoplasty was done in November, 1933, at which time the upper three ribs were removed. Re-study of the case two months later showed marked clinical improvement, a normal temperature chart, a reduction in cough of 75 per cent., and a diminution in the amount of expectoration by two-thirds. A röntgenogram taken then showed marked reduction in the size of the cavities on both sides (Fig. 11). The trachea and the upper mediastinum had moved toward the unoperated side and the cavity on this side was much smaller. The most extensive persisting cavitation, however, was found below the area of resec-

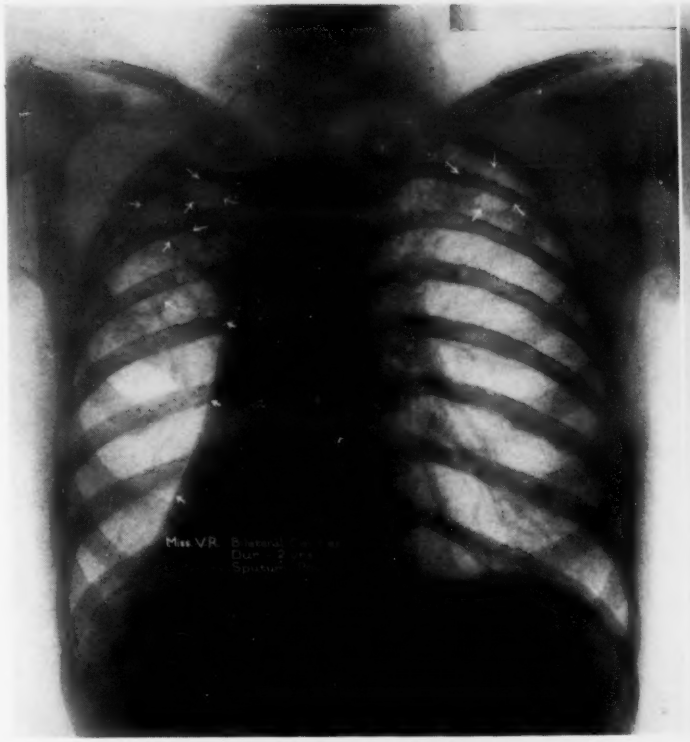

FIG. 10.—Pre-operative röntgenogram in Case V. R., aged twenty-eight, showing extensive bilateral cavitation. Duration of illness two years. Duration of stay in sanatorium, one and one-half years. Pneumothorax unsuccessful. Phrenic nerve paralysis not attempted. Classified, far advanced, active case. Recent extension on left.

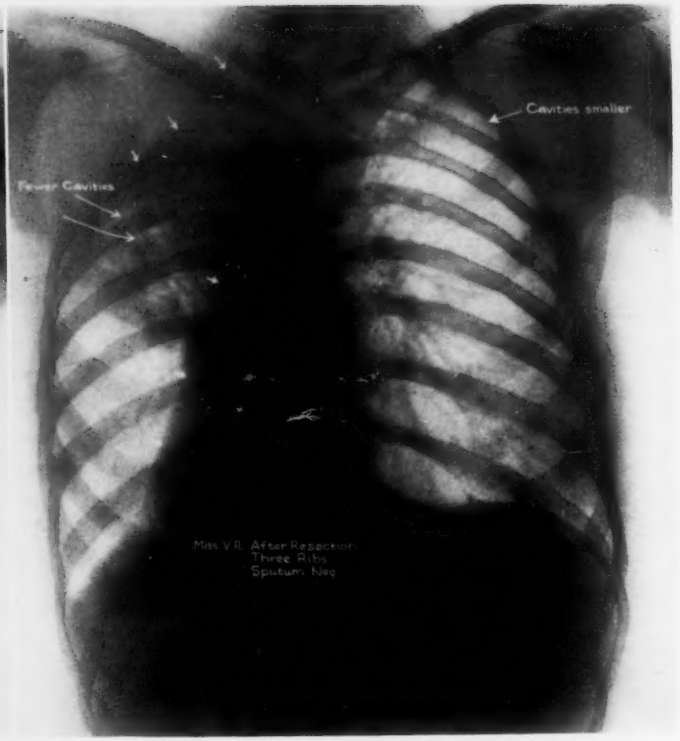

FIG. 11.—Röntgenogram in case of bilateral pulmonary tuberculosis two months after limited upper left thoracoplasty (Fig. 10). Note marked decrease in area of involvement on the left and also note the diminution in size of cavities on the right. At this time, the sputum was negative.

tion on the left side. It was then decided to abandon the plan of doing a bilateral resection of the upper three ribs and remove instead the posterior segments of three more ribs on the same side (Fig. 12). This was done and the patient now has no cough or expectoration and is classified as a quiescent case. The sputum is negative. There is illustrated here what may be accomplished by limited upper thoracoplasty in bilateral disease.

It is presumptuous to discuss end-results in the present series of patients. The present status, however, of these patients is shown in Tables I and II. This constitutes a preliminary report and shows the trend toward partial

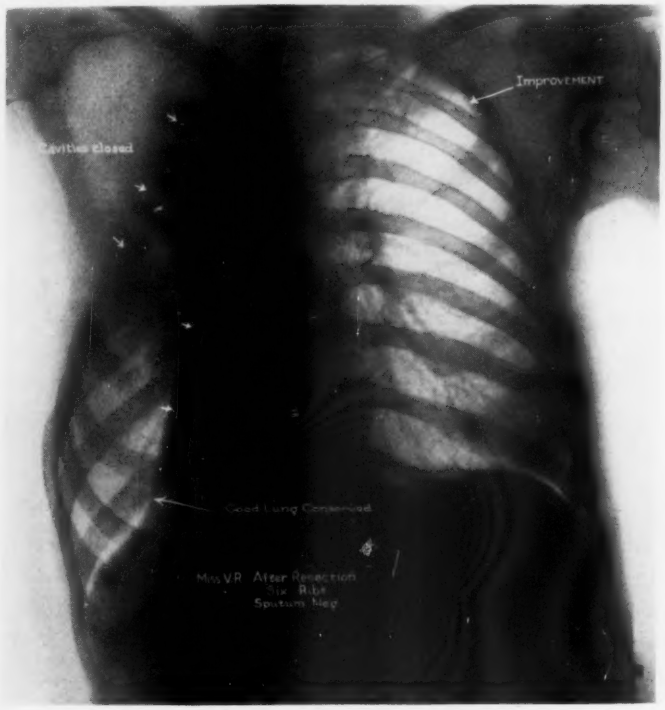

FIG. 12.—Röntgenogram in Case V. R., after second-stage thoracoplasty. In view of marked improvement on right side, the second-stage operation was carried out on the left side and three more ribs resected. Note extent of collapse. Note conservation of good lung at the left base. Note improvement at the right apex. Patient had a negative sputum and is classified as a quiescent case.

thoracoplasty. It was mentioned before that up to February, 1934, 120 thoracoplasty operations had been performed on seventy-three patients. In thirty-five patients, the collapse therapy has been completed and a sufficient period of time has elapsed to pass judgment on these cases. All that can be done to collapse disease lung tissue has been done for these patients. Of this number, thirty-four have had their cavities closed as shown by X-ray. The sputum has been consistently negative in thirty. Two patients have been listed as unimproved. Both of these cases were complete thoracoplasties in patients who had arrested tuberculosis. Both patients had marked mediastinal and

cardiac displacement due to fibrous contraction. In both cases, complete thoracoplasties were performed to relieve cardiac symptoms which were thought to be due to the pull of the fibrotic lung. No appreciable change in these cases has been noticed so far. The remainder, or thirty-three patients, have been improved. Seven are now classified as quiescent and eighteen are now apparently arrested. Fifteen of the apparently arrested cases have been discharged from their respective sanatoria.

SUMMARY

The value of selective or limited upper thoracoplasty in the collapse therapy program has been discussed. Emphasis has been placed upon the following points:

1. Pulmonary cavitation represents the discrepancy between the size of the thorax and the size of the underlying lung.

2. Thoracoplasty adjusts the size of the thoracic cage to the size of the remaining healthy lung.

3. A thoracoplasty should be so planned that maximum collapse of involved lung and minimum collapse of healthy portions of lung be the result.

4. The portion of the thoracic cage to be resected should not only include that part of the thoracic wall over areas of cavitation, but should extend sufficiently to relax fibrotic uncavitated lung.

5. The collapse obtained in the area treated should be complete within itself with each stage. In order to accomplish this, long or complete rib and transverse process, resections should be carried out beginning at the top of the thoracic cage.

6. The length of time between stages should be long enough to allow an accurate estimation of the necessity for, and the extent of, a second rib resection. This period of time should also be of sufficient length to permit the patient to receive the maximum benefit from the first operation before the second one is attempted.

7. The operation can be offered to patients with a relatively small amount of involvement of the upper portion of one lung because the base on the same side is conserved. The operation can be offered to cases with bilateral disease who have good lower lobes and who otherwise would have no hope for recovery.

8. A preliminary report of 120 operations in seventy-three patients is given, the operative mortality being 2.5 per cent. and the patient mortality 4.1 per cent.

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OBSCURE PSEUDOMEMBRANOUS TRIGONITIS

TRIGONITIS AREATA ALBA

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of Philadelphia, Pa.

Few things have been more baffling to the physician than a determination of the cause of marked frequency of urination in the female patient whose urine is normal in every way. Anything that can shed light upon so annoying a problem is of great value to those who suffer for weeks, perhaps years, from this symptom. The patient whose frequency is associated with pyuria usually has a reasonably correct diagnosis made and has treatment directed at the cause of the pyuria to which it is secondary. The other patients receive cystoscopic and many other types of study, and, because nothing is found to explain things, frequently are classified as neurotic and have their nervous systems treated without much relief.

While there are many things that can and do cause urinary frequency in the female, the lesion herein discussed accounts for a large proportion of those associated with normal urine. Also, it accounts for the symptoms of some patients who do have pyuria, though the pyuria usually results from some definite urogenital infection, as shall be seen by a study of the accompanying tabulation of cases. That the frequency often is not directly due to this infection is shown by the readiness with which it can be removed though the infection persists.

A number of the patients presenting this trigonal lesion experience a frequency of urination for months or years. The greater number, however, suddenly, and without apparent cause, are seized with acute attacks of the symptom which lasts from two weeks to a number of months. These shorter attacks disappear as suddenly as they came but show a tendency to recur from time to time. The severity of symptoms depends in a measure upon the particular type nervous system the patient happens to have, but it depends to even a greater degree upon the exact location of the lesion. The nearer to the vesical outlet it happens to be, the greater are the symptoms it produces. If, as occasionally happens, it passes into the grasp of the sphincter muscle, urination is followed by vesical tenesmus and at times a few drops of blood.

In 1924, under the title of "Trigonitis Areata Alba," the writer[1] described the lesion which had been encountered a number of times prior to that date. This article was published as a letter and apparently attracted little attention, as many of the cases herein reported had been subjected to cystoscopic studies by cystoscopists of wide experience without a discovery of the true cause of the symptoms.

That this lesion is not a rare one is shown by the fact that in an office

practice made up mostly of males it has been encountered in forty-two women in the last nine years.

That the lesion should escape observation is not to be wondered at, for unless one is familiar with it, it can easily be overlooked. In fact, it differs so little from the surrounding mucous membrane that it commonly is invisible when looked at directly. Usually, it is necessary to manipulate the cystoscope so that one looks diagonally at it in order to determine its presence. In appearance it looks exactly as though the surface had been touched with the weakest solution of silver nitrate that possibly could make a slight blanching of the tissue. It always is confined to the trigone and singularly enough is almost always on the right side in front of the right ureteral orifice. From here it extends for varying distances toward the vesical outlet. Occasionally these lesions extend into the urethra. Rarely they are on the left side and even more rarely they cover the entire trigone.

They do not resemble greatly true pseudomembranous trigonitis as illustrated by Wossidlo[2] and Pilcher,[3] nor are they nearly so obvious as that illustrated by Macalpine.[4] All of these are so outstanding that they could not be missed by any cystoscopist. Not only are the lesions in question far paler than these, but in no case did they increase in density sufficiently to become easily discerned on casual study. They bore no resemblance whatever to true leucoplakia, which may occur on any portion of the bladder wall, though it of course is more likely to be confined to the base.

Etiology.—There is so little uniformity in the histories and other findings in the cases seen that it is not possible to arrive at an opinion as to the true cause of obscure pseudomembranous trigonitis. Surely it cannot be due to anything of great pathological importance or the lesion and the symptoms it produces could not be banished so quickly and easily.

When one's cystoscopic eye sees such lesions his mind naturally wonders what submucosal changes could cause such a surface change, for the generally normal urine would seem to negate the possibility of their being due to surface influences alone. He who thoughtfully studies many female bladders soon learns to look for extravesical changes as the possible causes of circulatory or lymphatic variations from normal, and to view many bladder pictures as the reflections of such variations. Among the most common of these are, of course, birth traumas, pelvic inflammatory diseases and pelvic operations, and of less importance are the sexual and menstrual congestions. In the earlier series of cases it looked as though these latter, particularly the sexual, might play a part. In the present series the marital state and age incidence has so reversed itself as to belittle both as likely factors. In the former smaller series single women predominated, but in the present series only six were unmarried, and the ages varied from twenty-one to seventy-one years.

Of the outstanding points in the histories might be mentioned the following: Eight patients had had pelvic operations at varying periods before the onset of symptoms, six had microscopic pus from one kidney pelvis,

two had cystitis, one had cystitis colli, one a urethral stricture, two a mild degree of cystocele, one a chronic urethritis, and four a history of having had gonorrhœa.

There was nothing to suggest childbearing as a cause. Sixteen had nothing of a pelvic nature in the history and only seven had pus in their urines. All of the other urines were chemically and microscopically normal. Twenty had had from one to a large number of previous attacks. From such an assortment of possible causes, together with a total lack of things of a suggestive nature in so many of the patients, it obviously is not possible in the present state of our knowledge to definitely state the true cause.

Symptoms.—The most constant symptom of the condition was frequency of urination. It was present in all but one patient whose lesion was seen in a cystoscopic study occasioned by a known renal lithiasis. The duration of this frequency of urination ranged from a few days to twenty years.

The next most frequent subjective symptoms were vesical tenesmus and burning upon urination, which occurred in twenty-three and fifteen cases, respectively. Seven had pyuria, which was usually microscopic, and five had terminal hæmaturia.

The severity of the symptoms varied to some extent with the nervous make-up of the patient, as would be expected, but their character bore a more direct relation to the trigonal location of the lesion. Patients in whom the lesion was confined to the posterior portion of the trigone had frequency of urination alone, whereas those in whom the lesion approached or passed into the vesical outlet experienced the more severe symptoms of burning or tenesmus and, at times, the appearance of a few drops of blood at the end of urination. At times there was not a true vesical tenesmus in these cases but a period of vesical discomfort lasting for some time after urination.

Diagnosis.—While the true diagnosis rests upon the cystoscopic discovery of the lesions themselves, the presence of the symptoms in an otherwise healthy woman presenting a normal urine is highly suggestive. It will be seen by reference to the accompanying tabulation (Table I) that only seven of these patients had pus in their urines. The presence of a few red blood-cells in the urines of those presenting tenesmus of the severer type and giving a history of terminal bleeding would be as suggestive as a normal urine. A history of symptoms of long duration in the absence of marked evidences of urogenital pathology as well as a history of one or more previous attacks likewise would have high suggestive value.

Clinical Course.—There obviously are two types of the disease. The first, and vastly more common type, is characterized by a sudden onset and a duration varying from a few weeks to several months. Its cessation is so sudden as to leave one with the impression that it came as the result of the last medicament that was given. This frequently is proved not to be the case by the fact that the same drug has no influence upon a later attack. These seemingly self-limited attacks show a definite tendency to recur at varying

periods ranging from a few months to several years. Twenty of the patients herein reported had had previous attacks and a few had later attacks.

TABLE I

Diagnosis and Symptomatology

Case	Marital State	Age	Duration of Attack	Previous Attacks	Frequency of Urination	Burning	Pyuria	Terminal Bleeding	Tenesmus	Other Urinary-tract Pathology	Past Data
1	M.	55	3 mos.	+	+				+		
2	M.	71	6 wks.		+						
3	M.	34	2 mos.	+	+	+		+	+		
4	S.	48	3 mos.	+	+	+			+		Attacks each April and May
5	M.	48	2 wks.		+		+		+	Pus from left ureter	
6	M.	39	1 yr.		+						
7	M.	29	5 mos.		+						
8	M.	21	18 mos.		+	+			+	Early renal infection	
9	M.	30	2 mos.		+						
10	M.	28	5 yrs.	+	+		+	+	+	Left pyuria, oxaluria	
11	S.	30	1 yr.		+				+		Appendectomy
12	M.	46	10 days		+		+		+	Hæmorrhagic cystitis	
13	M.	57	20 yrs.		+		+			Destroyed left kidney	
14	S.	27	5 yrs.		+	+					
15	M.	24	4 yrs.		+				+		
16	M.	22	2 yrs.	+	+	+			+		Gonorrhœa, pelvic evisceration
17	M.	37	3 wks.	+	+						Gonorrhœa
18	M.	53	18 mos.	+	+						Plastic operation of perineum
19	M.	59	10 days	+	+			+	+	Chronic urethritis	
20	M.	27	4 yrs.		+		+			Staphylococcic pyelitis	
21	M.	22	2 mos.	+	+						
22	M.	52	1 yr.	+	+					Urethral caruncle	
23	M.	47	20 yrs.		+			+			
24	M.	25	6 mos.		+		+		+		Gonorrhœa, pelvic evisceration
25	M.	35	7 wks.		+	+			+		Hysterectomy
26	M.	36								Cystocele renal stones	
27	M.	36	15 yrs.		+	+			+		Uterine suspension
28	M.	28	3 days	+	+	+		+			
29	M.	58	3 yrs.	+	+				+	Cystitis colli	
30	M.	42	6 mos.	+	+				+	Pyelitis	Gonorrhœa
31	M.	51	1 mo.	+	+	+			+		Hysterectomy
32	M.	48	6 wks.	+	+	+					Pelvic operation
33	M.	45	1 mo.	+	+	+					
34	M.	24	7 mos.		+	+			+		Pelvic operation
35	S.	35	18 mos.		+	+	+		+	Chronic cystitis	Appendiceal abscess, adhesions to bladder
36	S.	37	11 mos.	+	+				+		
37	M.	30	3 mos.		+				+		
38	M.	20	7 mos.		+					Retroverted uterus, slight cystocele	
39	S.	26	3 mos.		+	+					
40	M.	46	10 days	+	+	+					Attacks each summer
41	M.	31	6 mos.	+	+				+		
42	M.	40	1 mo.	+	+				+	Urethral stricture	

The less usual type of the disease presents a long history of urinary frequency, which in two cases had lasted twenty years. Thirteen of these cases

had had symptoms for a year or longer, of whom six had had previous shorter attacks. This is hardly enough to suggest that the shorter attacks were forerunners of the other from a causative standpoint.

Prognosis.—Except for the annoyance of the symptoms the condition is of but little serious importance. That it has no definite relation to any major pathological condition is shown by the ease with which it usually can be cured even in the presence of other urogenital pathology. The tendency to later recurrences has been alluded to previously.

Treatment.—For so annoying a condition obscure pseudomembranous trigonitis lends itself very kindly to treatment. All but a comparatively small number of these patients are quickly rendered symptom-free by the local use of dilute solutions of silver nitrate. In the milder cases this is carried out by injecting perhaps a half ounce of 1 per cent. solution into the entirely emptied bladder and allowing it to remain until the next urination. Two or three days later 2 per cent. solution should be used and, if this does not cause too much burning 3 per cent. may be used in a like manner several days later. These solutions should be passed in through a catheter so that none of the solution touches the urethra, as even these strengths cause intense urethral burning and purulent discharge in some patients.

In the more severe grades and occasionally in some extremely nervous patients, it is well to keep the catheter in the bladder several moments, evacuate the silver nitrate solution at that time, and then inject half an ounce of one of the sedative oils, such as 20 per cent. oil of gomenol or a mixture of 3 per cent. guiacol, 5 per cent. calomel in olive oil. The oil should be held until the next urination.

Occasionally those patients whose lesions enter the vesical outlet are entirely cured only by the passage of urethral sounds sufficiently large to stretch the canal greatly.

Upon rare occasions neither of these treatments is successful. In such cases one meets with prompt success as a rule by directing 5 per cent. silver nitrate solution upon the lesion by means of a bevel-ended ureteral catheter when the bladder is full of fluid so that the solution is diluted immediately after it leaves the mucosal surface.

The administration of drugs by mouth to relieve symptoms does not cure the condition. In the writer's experience the only thing that has given much relief when administered orally has been calcreose. Given in doses of from two to four tablets of plain calcreose, four times a day, the urine smells strongly of creosote and it is possible that the relief comes by virtue of there being sufficient creosote present to exercise a mild anæsthetic influence. Be this as it may, the fact remains that it does not of itself banish the causative lesion.

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THE RELATIONSHIP OF CHOLECYSTITIS AND CHOLECYSTECTOMY TO DILATATION OF THE CHOLEDOCHUS

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It is common knowledge that a dilatation of the choledochus often follows the removal of the gall-bladder. This has been observed frequently in experimental animals, especially in the dog. A similar effect of cholecystectomy has been thought to occur in man. Several theories have been offered to explain this dilatation. After the removal of the gall-bladder with its absorptive powers and distensibility, the entire secretory pressure of the liver is thrown against the walls of the choledochus and the sphincter of Oddi. As this pressure is nearly twice that usually found in the common duct it might produce dilatation. However, we know that following the removal of the gall-bladder in dogs the sphincter of Oddi loses most of its tonus and the intraductal pressure falls to a much lower level than when the normal gall-bladder is intact. If this is a constant and early result of cholecystectomy the dilatation could not be explained on the basis of an increased intraductal pressure. While attempting to gain more information experimentally on this problem it was felt advisable to carry out studies on the choledochus in man.

In a series of consecutive autopsies the circumference of the choledochus was accurately measured midway between the union of the cystic and common hepatic ducts and the ampulla of Vater. The cases were then divided into two groups, those in which the extrahepatic biliary tract was grossly and microscopically normal and those in which it showed some pathological change. In the former group there were 527 cases, in the latter 128.

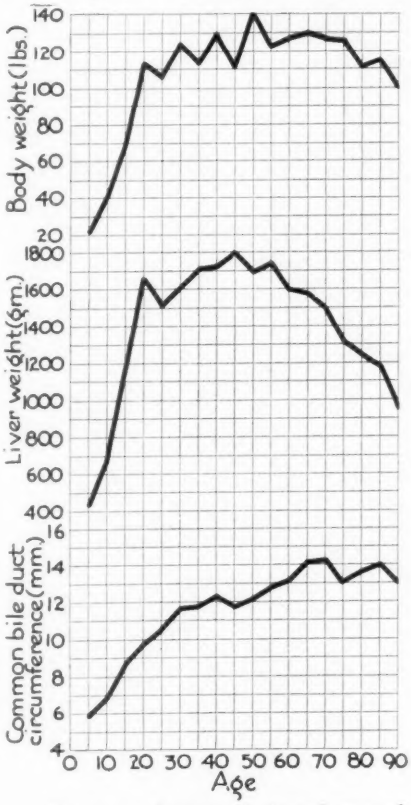
The "normal" cases were classified as to age, sex and color. The body length, body weight and liver weight were recorded in each case as well as clinical and pathological findings. Averages of all individuals in each five-year period from birth to ninety years of age were computed. Graph 1 shows these averages for the circumference of the choledochus, liver weight and body weight. The circumference of the common duct gives a fairly regular curve measuring six millimetres in infancy and increasing to an average maximum of fourteen millimetres at seventy years. The most rapid increase occurs in the first thirty years of life after which there is a slow increase with no appreciable decline in old age. The average liver weight increases rapidly in early life reaching a maximum at forty-five years and then diminishes quite rapidly with increasing age. The curve of body weight conforms fairly well to that of liver weight and does not decline as rapidly in old age. Although there was considerable individual variation in each age group the majority of measurements conformed quite closely to the average. The averages were determined and separate graphs of the circumference of the choledochus

TABLE I.

	No. of Cases	Normal: Average Circumference of Choledochus	Pathologic: Number of Cases: Cholecystitis without Stones	Cholecystitis with Stones	Previous Cholecystectomy	Common-duct Obstruction	Total	Per Cent. of Total Cases Showing Pathology	
White Male	218	11.9 mm.	15	34	3	8	60	21.6	24.6
White Female	94	12.5 mm.	9	26	5	2	42	30.9	
Black Male	118	11.3 mm.	7	2	1	0	10	7.8	10.8
Black Female	97	11.9 mm.	8	8	0	0	16	14.1	
Total	527		39	70	9	10	128	19.5	
Average Circumference of Choledochus		12.1	12.2	15.2	20.9	37.9			

plotted for both sexes of the white and colored races. These coincided fairly well but showed a slightly larger duct in females as compared to males and in the white race as compared to the Negro (See Table I).

The routine necropsies showing pathology of the extrahepatic biliary tract were divided according to the lesions found into the following groups: cholesteatosis and cholecystitis without stones (thirty-nine cases), cholecystitis with cholelithiasis (seventy cases), previous cholecystectomy (nine cases), definite common-duct obstruction (ten cases). When these are grouped according to sex and color they show a greater incidence of biliary disease in the female and in the white race. They also show a greater percentage with calculi in the white race than in the Negro. The average circumference of the choledochus was computed according to age in each pathological group and graphs made.



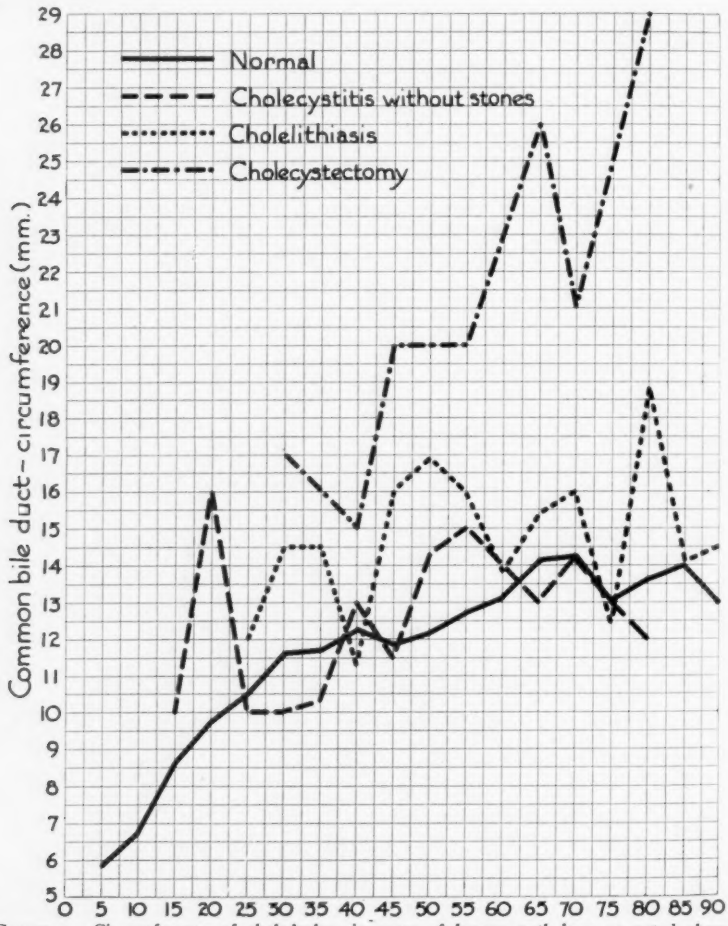
GRAPH 1.—Average of circumference of choledochus in comparison with the liver and body weight.

Graph 2 shows that in the presence of cholecystitis without stones there is very little if any dilatation of the choledochus. The average circumference for this group was only 0.1 millimetre greater than for the "normal" group. In the presence of cholelithiasis there was a greater dilatation of the choledochus, the average circumference of this group being 15.2 millimetres as compared to the normal 12.1 millimetres. However, in this group were included a number of cases in which calculi were found in the choledochus but no definite history of jaundice was recorded. These cases had a greater circumference than the average and increased this for the group. Where the gall-bladder had been previously removed there was a marked dilatation of the choledochus, the average circumference being 20.9 millimetres and every case had a greater measurement than the "normal" average. As would be expected there was a marked dilatation of the duct where a definite obstruction existed.

Of this entire group both normal and pathologic, sixteen had previously had cholecystograms. In thirteen the gall-bladder did not visualize. Five of this group did not show cholecystic disease and had an average common-duct circumference of 14.6 millimetres. Six had some obstruction of the choledochus with dilatation. Three have a gall-bladder shadow but all were pathologic and the average measurement was 16.3 millimetres. The findings of this group of cases suggests that the same degree of dilatation of the chole-

dochus does not occur in gall-bladders reported non-functioning röntgenographically as occurs following cholecystectomy.

This study can be criticized from several standpoints. The number of pathologic cases is fairly small. Measurements were obtained after post-mortem changes may have altered the structure and size of the ducts. However, all cases were studied under similar conditions and comparative studies should be of some value.



GRAPH 2.—Circumference of choledochus in cases of known pathology as noted above.

Summary.—In an effort to determine the relationship of cholecystitis and cholecystectomy to dilatation of the choledochus, studies were made at 655 necropsies. A graph according to age was made of the circumference of the choledochus in cases with normal biliary tracts and in those showing disease. Very little dilatation of the common duct was associated with simple cholecystitis. A slightly greater degree occurred in cholelithiasis. When the gall-bladder had been previously removed the dilatation was quite marked. These studies suggest that dilatation of the choledochus following cholecystectomy occurs in man as has been previously noted in animals. The same degree of dilatation does not accompany cholecystitis.

THE STATE OF UNILATERAL ANURIA IN BLADDER MALIGNANCY

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In 1927 the late Dr. Arthur L. Chute[1] drew attention to the death of patients from renal insufficiency in advancing carcinoma of the bladder. Doctor Chute entitled his paper "The Part that Obstruction of the Ureter Plays in the Outcome of Cancer of the Bladder." He had observed fourteen autopsies on cases of bladder malignancy, and states: "The main point of interest is this, that in these fourteen autopsies we found twelve cases in which a ureter was more or less dilated due to compression by disease; in four of these instances both ureters were dilated." It was through this communication that our attention, I believe, was first accurately focused on the occurrence of an obstructive uropathy with uræmic death in patients suffering from bladder malignancy. Chute continues by saying: "These findings suggest to me that dilatation of the ureters may be a pretty general occurrence in cases of carcinoma of the bladder and account for a considerable element of the mortality in these cases." In this communication, as well as in two others,[2, 3] he accentuates the finding of ureteral dilatation and discusses the part played by the malignancy in causing this dilatation by obstruction to normal ureteral function. I believe we have accepted the same as a most pertinent clinical observation, and a simple example of an obstructive uropathy with concomitant hydro-ureters, hydronephrosis and increasing renal insufficiency.

Our general knowledge of ureteral and renal pelvic function fits into this picture. We know and expect with sudden complete blockage (such as ligation of one ureter) an acute increase of pelvic pressure and, in the absence of infection, a rather prompt unilateral cessation of renal function, while, in contradistinction, a gradually developing blockage is uniformly accompanied by first an hypertrophy and later a constantly increasing hydronephrotic dilatation. Certain it is that any obstruction arising from a malignant bladder growth would belong to the latter group of gradually developing blockage and find its corollary in the picture so well described by Chute and generally recognized in other partially obstructive conditions. There certainly is no reason to expect that a bladder tumor would cause, at any time, sudden and complete occlusion and be comparable to a ureteral ligation.

Since the introduction of intravenous urography, I have been studying early cases of malignant bladder tumor by this method, in an effort to appraise the proper cases for ureteral transplantations and total cystectomy. In the past two years, out of fifty-nine cases of bladder malignancy, we have studied fifteen cases of particularly localized tumor by intravenous urography. While four of these fifteen cases have evidenced normal bilateral function, and four others varying degrees of hydronephrosis, as depicted by Chute, seven cases have surprised us with pictures of apparently unilateral nonfunctioning kidneys. In each of these seven cases the urograms have shown

on one side a shadow of an apparently normal renal outline but, in no plate, the slightest evidence of excretory function therefrom. In each of these seven cases the dead kidney is on the same side as the evident bladder growth, and one cannot separate the obvious relationship between tumor, ureteral involvement and the unilateral failure of renal function. In each of these cases this renal death has been silent, entirely symptomless and totally unsuspected. The one outstanding fact has been the apparent total absence of evidence of hydronephrosis, even in the films taken three and up to five hours after injection, and one begins to think, not of a disuse atrophy, but of a silent renal death, or a unilateral reflex anuria. These patients have not shown any symptoms of renal embarrassment and have not evidenced an elevated blood chemistry.

COMMENT.—One can theorize along several lines to account for these findings: First, there certainly is no reason to expect a sudden and complete occlusion that would allow this condition to be compared with ureteral ligation or complete stone blockage. Second, in the absence of infection, it should be to a degree comparable with partial stone obstruction or pregnancy, but the parallelism stops there, for in these latter conditions marked hydronephrosis is outstanding. Third, from the study of our films the kidney shadow appears quite normal, and the frequency of the occurrence as observed in these seven cases rules out chance pathology. Fourth, in those cases where time has allowed of a repeated observation, we have not observed any change in the renal picture or function, and this in spite of the fact that in one outstanding observation the tumor had decreased at least 70 per cent. in size under fulguration and irradiation treatment, and has been studied repeatedly over a period of ten months.

It is our belief that these kidneys are physiologically dead and have no power of recuperation. One turns naturally to seek an explanation in other bodily functions where somewhat comparable conditions are recognized to exist, and there comes to mind the frequency of pylorospasm in appendiceal irritation and in hyperchlorhydria; likewise the negative gall-bladder function in duodenal ulcer; and one might think of this unilateral suspended uropoiesis as perhaps a protective reflex where, with one unhampered kidney to carry on the required bodily work, its embarrassed mate ceases to function.

In substantiation of this theory we have cases where the malignant growth covered the bladder base to an extent that unquestionably involved both ureters, and in these differing degrees of bilateral hydro-ureters have been present, evidencing the fact that, when vital renal function is truly embarrassed, the bodily response is quite different, for then a fight is on, which calls forth the utmost compensatory function and fails only after marked hydronephrotic destruction has transpired.

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THE HÆMORRHAGIC TENDENCY IN OBSTRUCTIVE JAUNDICE*

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The tendency to spontaneous and post-operative hæmorrhage in patients with obstructive jaundice has for years attracted the attention of clinicians and investigators. It is now a well-recognized fact that neither the bleeding nor the coagulation time is of any value in prognosticating post-operative hæmorrhage. Even when a prolonged coagulation time is brought to within normal limits by therapy prior to operation, post-operative hæmorrhage may occur.

It was to be hoped, following Linton's[1] very interesting paper, that the sedimentation rate of the blood would offer information of prognostic importance but the sedimentation rate may be profoundly altered by so many factors which may be coincidentally associated with obstructive jaundice that our hopes were not long lived. Anæmia, infection, tissue injury, and dehydration are frequently present and although each of these may affect the sedimentation rate it may play little or no part in preventing the blood from clotting normally. The subsequent studies of Clute and Veal[2] and Carr and Foote[3] showed that this method was not reliable in determining the presence of an hæmorrhagic tendency. Since there is so little factual information on the mechanism of the clotting process, it is to be expected that the causes of alteration from the normal may be difficult to determine.

Calcium.—Many years ago Mayo-Robson suggested that the hæmorrhagic tendency of the jaundiced patient was associated with a deficiency in available calcium and that the disturbed calcium balance might be restored, with benefit to the patient, by its pre-operative administration. It is possible that Mayo-Robson had in mind the conclusions reached by King and Stewart[4] who stated that in jaundice the calcium reserve was combined with the bile-pigment in the blood and was not available for the clotting process. The experimental proof of the latter investigators is, however, not convincing. It was not until Whipple[5] and Walters[6] popularized the intravenous administration of calcium salts in the jaundiced patient that their pre-operative use became widespread in this country.

At the time that calcium therapy was first suggested there were few studies of the serum calcium in jaundiced patients. The data of Halverson, Mohler and Bergeim,[7] Koechig,[8] Walters and Bowler,[9] and Snell, Greene and Rowntree[10] and ourselves[11] strongly indicated that the serum calcium in jaundiced patients was within normal limits. In 1927, however, Buchbinder

*Aided by a grant from the Josiah Macy, Jr., Foundation.

and Kern[12] reported a reduction of the serum calcium in young puppies and in three patients with obstructive jaundice. The data of these workers and those of Kirk and King[13] and Carr and Foote[3] stand alone in a wealth of data which has now been accumulated. In Table I are given some data which include the minimum and maximum serum calcium figures we have obtained in a now large series of dogs and patients suffering from obstructive jaundice.

TABLE I

The Serum Calcium in Obstructive Jaundice

Dog	Serum Calcium mg. per cent.	Patient	Serum Calcium mg. per cent.
7	8.9	J. B.	9.6
10	9.9	M. L.	10.5
1	10.3	B. R.	10.8
4	10.3	I. T.	10.9
2	10.5	J. H.	10.9
6	11.0	S. M.	11.1
8	11.2	M. C.	11.1
3	11.6	A. S.	11.2
9	11.8	C. D.	11.2
5	12.7	M. K.	11.3

From our studies we do not believe that the findings of Buchbinder and Kern[12] showing an inverse relationship between the degree of jaundice and the serum-calcium concentration will be substantiated by more extensive studies, since no such relationship can be demonstrated in either the jaundiced dogs or the patients that we have studied (Table II).

TABLE II

*Relation of the Serum Calcium, Phosphate, van den Bergh and Coagulation Time in Obstructive Jaundice**

	Calcium mg. per cent.	Phosphorus mg. per cent.	van den Bergh units	Coagulation Time minutes
Dog				
J. 8 N.S.	10.2	3.6	4.8	6.3
J. 10 N.S.	9.9	4.5	5.1	6.5
J. 9 N.S.	10.1	3.3	5.2	3.3
J. 7 N.S.	10.5	4.5	6.2	4.0
J. 5 N.S.	10.3	3.5	6.9	5.2
J. 6 N.S.	11.0	3.0	10.4	8.0
Patient				
M. C.	11.1		2.0	27.5
B. R.	11.2		3.5	2.5
H. H.	10.8		4.2	6.3
J. H.	10.9		4.9	10.5
M. D.	11.2		7.5	8.5
H. S.	10.6		10.6	4.2
G. M.	11.1		14.5	12.6
A. S.	11.2		15.2	9.5
S. B.	10.5		25.0	2.5
M. L.	10.8		28.4	8.4

* Lee-White method.[31]

The available information on the effect of hypo- and hypercalcemia on the coagulation time of man or dog shows no constant change from the normal. We have observed a normal coagulation time in a young girl with parathyroid tetany who had a serum calcium concentration of 5.2 milligrams per cent., as well as in a patient with hyperparathyroidism who had a serum calcium concentration of 15.4 milligrams per cent.

In a number of papers an attempt has been made to differentiate the rôle of ionizable and non-ionizable calcium in the clotting process. Vines[14] has shown that the amount of oxalate, citrate, or fluoride necessary to retard or inhibit coagulation is in excess of the chemical equivalent of the calcium present in the specimen. Although Stewart and Percival[15] found that the ionizable calcium played no rôle in the process of coagulation, they believed that a complex protein—calcium compound—played some part in the process.

Gunther and Greenberg[16] have very thoroughly reviewed the relationship of the serum calcium to jaundice and have concluded that there was no proof of a calcium deficiency in obstructive jaundice, nor any direct proof that the diffusible or non-diffusible calcium was in any manner deficient. Only in those instances where there existed a considerable change in the serum proteins was there any alteration in the serum calcium distribution from the normal.

In five patients whom we have studied and who showed an hæmorrhagic tendency after operation, the diffusible calcium in the serum varied from 52.7 to 59.9 per cent. which is well within the normal limits. Other possible indirect actions of calcium will be discussed later.

Glucose.—It is undoubtedly true that the simultaneous use of glucose and calcium in the pre-operative preparation of the jaundiced patient has resulted in a marked decrease in the incidence of post-operative hæmorrhage. Since no deficiency existed in the serum calcium it seemed highly possible that the beneficial effect of the pre-operative treatment might be ascribed to the use of glucose prior to operation.

As early as 1894 Wright[17] had observed a decrease in the coagulation time after the ingestion of a meal. Thirty years later Cannon and Gray[18] showed that adrenalin, which mobilized the blood sugar, caused a reduction in the coagulation time. In 1929, Partos and Svec[19] reported a direct relationship between the blood sugar concentration and the coagulation time, but until our earlier studies[11] were published no data existed on the effect of glucose alone on the coagulation time of the jaundiced patient. In the studies reported prior to our report (Schreiber,[20] Kehr,[21] Walters,[6] Whipple,[5] and Mayo[22]) the use of glucose in the pre-operative preparation of jaundiced patients was invariably associated with the administration of calcium to prevent hæmorrhage.

There is much additional data in the literature to show that hyperglycemia is often associated with a reduction of the coagulation time, but in an extended series of studies we have failed to find any direct parallelism between the fasting blood sugar and the coagulation time (Table III).

TABLE III

The Relation between Serum Calcium, Blood Sugar and Coagulation Time

Dog	Serum Calcium mg. per cent.	Blood Sugar mg. per cent.	Coagulation Time minutes
J. 6 N.S.	11.0	92	8.0
J. 5 N.S.	10.3	86	5.2
J. 7 N.S.	10.5	96	4.0
J. 8 N.S.	10.2	88	6.3
J. 9 N.S.	10.1	98	3.3
J. 10 N.S.	9.9	103	6.5

Even when glucose is given in an effort to affect favorably the coagulation time, the maximum effect is often not obtained until some time following the injection, at which time the coagulation time is shortened as the blood sugar returns to a normal level (TABLE IV).

TABLE IV

The Effect of an Intravenous Injection of Glucose in the Jaundiced Dog

Dog 642, 10.2 kilograms	Coagulation Time minutes	Blood Sugar mg. per cent.	Calcium mg. per cent.	Phosphorus mg. per cent.
Before injection of 25 Gm. glucose	7.3	109	11.1	2.5
At completion of injection	5.5	542	11.6	2.4
Ten minutes after injection	2.0	260	11.8	2.8

Suffice it to state, however, that our earlier observations on the effect of glucose on the coagulation time have been confirmed and extended and we have found no reason to alter our conclusions that glucose alone given intravenously or by mouth favorably affects the coagulation time in both the normal and jaundiced dog and in patients with obstructive jaundice when the liver damage is not too great.

Later studies by Cowan and Wright[23] confirm in the main our findings. These investigators, however, believe that the effectiveness of the glucose is directly related to the rise in the serum calcium which they found to follow the glucose injection. This is not a consistent finding nor does it always parallel the rise in blood sugar or the decrease in the coagulation time. Furthermore, since the injection of calcium intravenously in larger amounts than that mobilized by an injection of glucose has little effect on the coagulation time, we are not at all sure that their statement that "the effectiveness of the increased calcium called forth by the glucose injection in reducing the coagulation time would indicate that this freshly released calcium was in a more readily available form for taking part in the clot formation than that already present in the blood, particularly in cases of jaundice." The data given by Cowan and Wright[23] are too few for generalizations, but they are interesting in that they confirm our observations on the effect of glucose on the coagulation time, though our findings do not agree with theirs in showing a consist-

ent rise in the serum calcium after glucose injections. It is not possible from the available data adequately to explain the action of glucose on the clotting process. In Table V are given additional data on the effect of glucose on the coagulation time of the jaundiced patient.

TABLE V

*The Effect of Intravenous Glucose Solutions on the Coagulation Time**

Patient	Coagulation Time	
	Before Injection minutes	After Injection minutes
A. S.	9.5	5.3
H. W.	16.0	6.5
R. H.	10.0	6.1
R. D.	18.2	2.5
S. B.	10.4	1.5
M. C.	27.5	4.4
J. H.	10.5	5.3
G. M.	12.6	7.6
H. H.	6.3	4.2
M. S.	14.5	5.7

* After three days of glucose treatment.

FIBRINOGEN.—We have previously reported[11] that preliminary results suggested that the injection of glucose caused no rise in the fibrinogen of the blood and Cowan and Wright state that they have confirmed these findings. It was supposed by some investigators that during obstructive jaundice there might exist a deficiency of available fibrinogen since obstruction of the common duct results in a variable degree of liver damage.

The important part which the liver plays in maintaining the blood-fibrinogen level has been studied by Foster and Whipple,[24] Howe,[25] Mann and Bollmann,[26] McMaster and Drury[27] and others. Although there is agreement that the liver is the chief source of the blood fibrinogen, it is generally agreed that the degree of liver damage necessary to produce a fall in the fibrinogen level is considerably greater than that met in simple obstructive jaundice. A variety of conditions often associated with obstructive jaundice, anæmia, infection and tissue damage, are in themselves often associated with an increase in the blood fibrinogen.

Moss[28] in a very interesting study investigated the fibrinogen in experimental obstructive jaundice and concluded that there existed no deficiency of fibrinogen in this condition. We are in complete agreement with his findings as can be seen in Table VI.

OTHER FACTORS.—It would appear from the data here presented that the hæmorrhagic tendency of the patient or animal suffering from an obstruction of the common bile-duct is not due to a deficiency of any known substance in the blood which normally takes part in the clotting mechanism. It has recently been suggested by Carr and Foote[3] that "taurine, cysteine and related products are the protein products which most probably back up in the blood

TABLE VI

The Plasma Fibrin after Common-duct Obstruction

Dog	Calcium mg. per cent.	Fibrin mg. per cent.	Sugar mg. per cent.	Remarks
563	11.2	801	105	Before operation
	9.8	915	– –	4 days after operation
	9.9	743	102	6 days after operation
547	10.5	606	– –	Before operation
	10.0	769	73	13 days after operation
599	9.6	880	105	Before operation
	10.3	1,195	105	3 days after operation
662	10.7	555	– –	Before operation
	11.4	697	81	17 days after operation
672	9.5	614	103	Before operation
	10.9	617	88	14 days after operation
737	10.8	712	– –	Before operation
	12.2	1,000	– –	10 days after operation
852	11.5	705		Before operation
	10.4	878		10 days after operation
776	10.6	515		Before operation
	10.3	1,024		8 days after operation
823	10.8	925		Before operation
	12.6	743		7 days after operation

and collect in sufficient concentration in the circulating plasma to cause changes in the clotting mechanism." Thus, these authors believe that the hæmorrhagic tendency in obstructive jaundice is due to the addition of an inhibiting substance which in turn affects the clotting process.

The chemical evidence adduced by Carr and Foote for the rôle of cysteine in the hæmorrhagic tendency of obstructive jaundice is somewhat difficult to evaluate. The suggestion concerning the conversion of cysteine into dextrose is on quantitative grounds inadmissible, the amounts of dextrose which could possibly be derived from such a source being negligible. Furthermore, while sulphates are the normal products of cystine and cysteine metabolism we are not aware of any evidence that sulphites are end-products. The statement that "sodium plumbite will convert cysteine to disulphids" is not in agreement with the facts known to us. Sodium plumbite is used as a means of furnishing lead in alkaline solution for the precipitation of lead sulphide—a reaction which takes place with both mercaptans and disulphids.

The evidence presented for the isolation of bromphenylmercapturic acid lacks definite proof, moreover there does not appear to be sufficient quantitative distinction between the amount of this compound produced by jaundiced dogs and that produced by normal dogs under the same experimental conditions. It is to be regretted that the figures showing an increase in the ethereal sulphates in the later stage of the disease, as mentioned by the authors, were not given.

It has been our experience that in patients with complete common-duct obstruction hæmorrhage prior to operation is of rarer occurrence than post-operative hæmorrhage. Rather have we observed that hæmorrhage occurred at a time when bile was flowing freely from the common duct and the liver had had a chance again to resume, at least partially, its normal function.

It is a well-known fact that the administration of glucose profoundly affects the blood-guanidine concentrations observed after the liver necrosis caused by chloroform and carbon tetrachloride.

Should the mercaptans prove to be an important factor in the hæmorrhage of obstructive jaundice, the rationale of glucose therapy is still further strengthened since Abderhalden and Wertheimer[29] found that animals receiving brombenzene excrete practically no bromphenylmercapturic acid when on a high carbohydrate diet.

We have taken advantage of our association with Dr. James C. Andrews of the Department of Physiological Chemistry in this University to discuss with him sulphur metabolism. It is his opinion that there is a possibility that the clotting mechanism may be influenced through the effect of sulphur compounds on the blood calcium. It has been known for some years, according to Andrews,[30] that the presence of calcium or lead greatly increases the degree of deaminization of cystine, an effect which suggests the precipitation by these metals of some intermediate substance which protects the amino acid from deaminization. Since the most insoluble salts of many such compounds are to be found in the lead-calcium group, it is possible that some sulphur compound derived from cystine or cysteine is capable of precipitating part of the serum calcium or otherwise rendering it incapable of taking part in the clotting mechanism. This suggestion of Andrews is of course advanced purely on chemical grounds.

Regardless of the outcome of this extremely interesting and important problem, the fact remains that at present with the exception of blood carbohydrates by mouth or intravenously offer the best hope of preventing hæmorrhage in patients with obstructive jaundice.

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PRIMARY CARCINOMA OF THE LIVER WITH SPONTANEOUS RUPTURE AND LETHAL HÆMORRHAGE

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During the course of 27,000 autopsies performed at the Philadelphia General Hospital, a ruptured liver has been noted four times. One of these was the result of a fall from a hospital window, the second resulted from a crushing blow from a landslide, while the cause of the third hepatic rupture is unexplained in the records. The ruptured organ was in each case normal in size and free from disease. These patients presented other injuries, chief among which was the fracture of many ribs. Trauma is in fact the most frequent cause of rupture of the liver. The records of the fourth instance are herewith detailed.

Case Report.—May 28, 1933, there was admitted to the Medical Service of the Philadelphia General Hospital a Chinese male, aged sixty-six years. He was well nourished and complained only of some abdominal discomfort. For a period of two weeks before admission he had noted some swelling of his feet. He was free of headache, vertigo and cough. He had a good appetite, had no indigestion and his bowels moved regularly each day. He voided two to three times at night and had occasional dysuria. He denied all previous illnesses. He was a huckster and had been in the United States for fifty years. He was at one time a heavy drinker but never used drugs. He smoked "Chinese tobacco" in a "water pipe" and occasionally smoked a cigarette. He had never been married.

On physical examination he was not emaciated or jaundiced. There were no palpable lymph-nodes. The cutaneous veins were not distended and there was no dyspnœa. There were many carious teeth and much oral infection. Some fine râles were heard over both pulmonary bases posteriorly, and the pulmonary resonance did not extend to normal limits either anteriorly or posteriorly over the right chest. The area of cardiac dullness was within normal limits. The heart sounds were regular, with a rate of 80, of good quality and clear. The radial arteries were easily palpable, the arterial pressure was systolic 152, diastolic 95. The abdomen was rounded. There were no areas of tenderness and movable dullness was not noted. The liver was percussed as twenty-two centimetres in the right mid-clavicular line, twenty centimetres in the mid-sternal line, and fifteen centimetres in the left mid-clavicular line. Its palpable surface was for the most part smooth, with a few moderate-sized nodulations. It was not tender and the character of its edge was not discernible. The spleen was not palpable. There was no œdema of the extremities. Neurological examination disclosed nothing abnormal. The prostate was enlarged, not tender, smooth and of normal consistency. There were no hæmorrhoids.

During the course of his hospital residence, he had no other complaints, but developed an unproductive cough on the third day after admission. With it there came a mild evening rise in temperature, never above 100.0° F., and the scleræ became yellow-tinged. By June 7, his icterus index reached 50. The van den Bergh reaction was diphasic.

The usual urine examinations were normal except for the finding of bile pigment. The blood count was red blood-cells, 3,780,000; white blood-cells, 6,500; hæmoglobin, 70 per cent.; polymorphonuclears, 72; lymphocytes, 18; large mononuclears and transi-

tionals, 7; eosinophiles, 2; and basophiles, 1. Fasting blood sugar was 109 milligrams per cent. and the blood urea was 13 milligrams per cent. The Kahn reaction was negative. Blood culture was sterile. The fæces were negative for parasites and ova. Stool cultures showed a predominance of B. *coli communis* and *Streptococcus viridans*. The electrocardiogram was normal.

The patient would not coöperate during two efforts made to examine his gastro-intestinal tract by X-ray. A high right diaphragm with restricted movements was noted during fluoroscopy, but nothing unusual was reported in the chest.

It seemed certain that the patient had a carcinoma of the liver probably with some cirrhosis. That it was a primary lesion in this organ was strongly suspected.

On the morning of June 17, a nurse found him struggling for air, cold, clammy, weak and pulseless. The interne reached his bedside after death had occurred. He had had a quiet night and had had no unusual experience until immediately before death. The clinical diagnosis was carcinoma of the liver, probably secondary. The cause of death was unsuspected, although coronary occlusion seemed the most probable immediate cause of death.

At post-mortem examination, the abdomen was distended, and when opened the peritoneal cavity was full of dark red blood, some of which had clotted. Its amount was not measured by Doctor Bevan, who performed the autopsy, but her records suggest that more than one-third of the body's blood was free in the abdominal cavity.

Quoting from her notes: The liver weighs 4,900 Gm. The organ is enlarged to almost five times normal size. Its capsular surface is covered by large clots of blood and when these are removed greenish-yellow irregular tumor masses are seen rising above the level of the capsule. On section, the normal liver tissue is greatly atrophied in places, in others it has been pushed back until it almost forms a capsule around the tumors. The tumor masses vary in size, ranging from four to fifteen centimetres in diameter. They are distributed throughout the entire liver. When section is made through them, they seem to contain yellowish-green soft material which is necrotic in some places and can be pulled out. On the anterior aspect of the right lobe, one of these tumor masses has ulcerated through the capsular surface and the hæmorrhage can be traced back to this location. These tumor masses resemble those arising from biliary ducts. The sections examined by microscopy showed primary liver-cell carcinoma, acute and chronic passive congestion and parenchymatous degeneration.

The lungs—each weighs 300 Gm.—are well expanded and on cross-section their surfaces are grayish-red in color. A certain amount of œdema is present and blood-tinged frothy fluid may be expressed. The surface is studded with firm white nodules of varying sizes, ranging in diameter from one to ten centimetres. The tumor growths are rather sharply circumscribed and press back the surrounding lung tissue. Microscopical diagnosis of lung sections showed metastatic carcinoma, acute and chronic passive congestion, œdema and anthracosis.

Tracheal bronchial lymph-nodes are enlarged and on section reveal surfaces stained by anthracosis and present grayish tumor formation.

Stomach is fairly well preserved, its rugæ are prominent, the mucosa is negative for ulceration and primary or metastatic tumors. Microscopy showed acute passive congestion.

Intestines are lying in masses of blood-clots, but when these are removed the entire tract is found in good condition; it contains a small amount of fæces and is negative throughout its entire length for any metastasis or primary tumor. The rectum is especially examined and found negative for tumor. Microscopy showed acute passive congestion throughout the intestinal tract.

Pancreas is of normal size and consistency. Its cut surface appears somewhat reddened by congestion and glistening yellow fat is seen between the pancreatic lobules. By microscopy, fatty infiltration and acute passive congestion were observed.

Spleen weighs 200 Gm. The organ is approximately twice the normal size. Its

capsule is grayish-blue and of average thickness. On section, its pulp appears dark purplish-red with occasional white streaks. Throughout, it is much softer than normal and tears apart easily. There is no evidence of malignancy. The microscopical sections showed acute and chronic passive congestion, hæmorrhage, necrosis and fibrosis of the pulp.

The adrenals are quite firm and showed only slight epinephric degeneration and acute passive congestion.

The prostate is normal in size for age of patient. No areas of malignancy are found on section.

Kidneys—left weighed 150 Gm. and right 150 Gm. Normal in size and position. Capsule strips easily, revealing a dark gray surface, marked by occasional arteriosclerotic scars. There is marked eversion of the cut edge. The cortex and medulla are in normal proportions. Both appear hyperæmic. The architecture is well preserved. There is no evidence of metastasis. Microscopical diagnosis: Toxic nephrosis and acute passive congestion.

The aorta is in moderately good condition, there are a few atheromatous plaques present over the arch and at the level of the bifurcation. Some of these plaques have undergone ulceration and calcification.

The heart weighs 350 Gm. It is normal in size. The epicardium and pericardium are normal except for a few "soldier plaques," 1.5 centimetre in diameter, over the right ventricle. The myocardium is pale, greenish-red, it seems degenerated and lacking in muscular tone. The mural endocardium is smooth and glistening. The valves show nothing abnormal except for some thickness of the mitral leaflets and fibroses beginning at the base of the aortic leaflets. Both of these changes are insufficient to interfere with function. The chambers are of normal size. The coronary arteries have undergone some atheromatous changes with narrowing of the lumen but they are patulous throughout.

The literature of the last fifteen years contains only one reference to a case similar to the one here reported. "A man, aged thirty-four, with a history of chronic indigestion, was suddenly taken ill while at work, with symptoms simulating an acute surgical abdomen. The patient was not operated on and rapidly became worse, dying within four days. Necropsy revealed a primary carcinoma of the liver, which had ruptured spontaneously, filling the abdomen with one and one-half quarts of dark blood. It seems plausible that the jar from the tractor which the patient was driving was sufficient to cause the rupture in the liver." That such an accident does not occur more frequently is rather surprising. When it does so, however, it is easily understood as it is in our patient. The mobility of the liver, its position within the abdominal cavity, its architecture, its texture and capsule doubtlessly make for its infrequent rupture even when it is the seat of disease. It is less likely to occur in a normal liver. In the latter case, a direct blow breaking many ribs which serve ordinarily to protect this organ or a crushing force flexing the spine to an unusual degree will tear the liver. Our patient's liver was enormous and crowded the other viscera in the abdominal cavity; besides this, it was the seat of a rapidly progressing lesion in a subcapsular position. Under such circumstances the added strain of mild passive congestion, an unusual bodily twist ordinarily harmless or even the experience of having a bowel movement might precipitate a break in a capsule weakened by disease. Mast and Streamer,[1] in the case report referred to above, were

inclined to think of a ruptured peptic ulcer in their patient until the initial involuntary rigidity disappeared and the liver became palpable. Passive congestion of the liver seemed unlikely in view of the history and physical findings. With knowledge that the liver is the seat of disease, rupture should be thought of in the presence of a picture simulating a sudden acute surgical condition in the abdomen. A history of frank trauma will make the diagnosis more likely. Numerous reports in medical literature attest to the successful repair of hepatic tears in normal organs resulting from obvious traumatism. The length of life after this accident will depend upon the extent of injury and the rapidity and amount of hæmorrhage. The degree of resulting shock will determine the speed of recovery or death after the liver has been ruptured.

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ACUTE EMPYEMA IN CHILDREN

REPORT OF 310 CASES

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During the years 1920 to 1932 inclusive, 289 cases of acute empyema in children were seen at the Children's Hospital and the City Hospital of Akron. There were 7,030 surgical admissions at the Children's Hospital during that time and of this number 270 were cases of acute empyema, an incidence of more than 3.8 per cent. There were twenty-one cases at the St. Thomas Hospital during the four years since it opened.

Empyema in children has been the subject of many papers, but comparatively few cases have been reported where the disease was present at an earlier age than six months. Lilienthal[1] reported a case of bilateral pneumonia followed by acute empyema on the left side in a male infant of six weeks. The diagnosis was confirmed by X-ray and drainage resulted in complete recovery.

Glaser and Epstein[2] writing on empyema in the "new-born," by which they mean infants who are not more than three weeks old, found only three cases in whom symptoms had been noted. They pointed out that there is less empyema in "new-born" children since the prophylaxis of puerperal sepsis has been better understood. The case they reported developed symptoms the nineteenth day and the diagnosis was confirmed by X-ray. The patient died after several aspirations. They believe that in such small infants the condition is so desperate that intercostal drainage should be instituted. Pneumococci were not found in any of the reported cases coming under their observation.

Dodds[3] reported a baby delivered with the umbilical cord encircling the neck four times, who died in eighty-seven hours. Autopsy showed bilateral pneumonia and a large amount of pus in both pleural cavities. Cultures grew both staphylococci and pneumococci. Ormos[4] reported a well-developed child who died forty-seven hours following a normal delivery. Pneumococci were found in the pus from the thoracic cavities, and he believed the infection occurred after birth.

Of the 310 cases there were twenty under six months of age. The youngest was a premature infant admitted seven hours after birth, who died on the twenty-fourth day, and empyema was found at autopsy. In three of these cases pneumococcus was the causative organism, but most of the empyemas in the very young infants were found at autopsy and no cultures were taken.

The relation of males to females and the mortality rate was:

	Cases		Deaths	
		Per Cent.		Per Cent.
Male	186	(60)	40	(21.5)
Female	124	(40)	30	(24.2)
Total	310	(100)	70	(22.6)

Bosch[5] mentioned that boys are affected more frequently than girls. Cameron[6] found that males outnumber females two to one, but did not find that sex influenced mortality.

TABLE I

Number of Cases and Deaths by Years

Age	Number of Cases	Per Cent. of Total Cases	Number of Deaths	Per Cent. of Deaths by Years	Per Cent. Total Deaths	Deaths Per Cent. Total Cases
0– 6 months.....	20	6.5	16	80	22.9	5.2
7–12 months.....	11	3.5	6	54.5	8.6	1.9
1– 2 years.....	33	10.6	15	45.5	21.4	4.8
2– 3 years.....	30	9.7	9	30	12.9	2.9
3– 4 years.....	26	8.4	2	7.7	2.9	0.6
4– 5 years.....	33	10.6	2	6.1	2.9	0.6
5– 6 years.....	31	10	1	3.2	1.4	0.3
6– 7 years.....	31	10	5	16.1	7.1	1.6
7– 8 years.....	30	9.7	7	23.3	10	2.3
8– 9 years.....	21	6.8	0	0	0	0
9–10 years.....	5	1.6	0	0	0	0
10–11 years.....	5	1.6	0	0	0	0
11–12 years.....	9	2.9	4	44.4	5.7	1.3
12–13 years.....	12	3.9	0	0	0	0
13–14 years.....	5	1.6	1	20	1.4	0.3
14–15 years.....	5	1.6	2	40	2.9	0.6
15–16 years.....	3	1	0	0	0	0
Total.....	310	100	70			22.6

In Table I the incidence according to age is listed together with the mortality for each age group and the relation to the total mortality. In Table II these figures have been combined with those given by several other authors. Of the 310 cases practically 80 per cent. occurred in the first seven years. During this period there is a great difference in the mortality rate. Of those having empyema during the first year of life 71 per cent. died, in the second year 45.5 per cent., and in the third year 30 per cent. The mortality drops to 7.7 per cent. for the fourth year, 6.1 per cent. during the fifth year, and 3.2 per cent. for the sixth year. The rate is higher again for children seven years of age, being 16.1 per cent., and 23.3 per cent. during the eighth year. In the sixty-five cases from nine to fifteen years inclusive there were only seven deaths.

The highest death-rate occurred in the first six months of life when sixteen (80 per cent.) out of twenty died. From seven to twelve months there were eleven cases with six (54.5 per cent.) deaths. There were seventy deaths in the 310 cases, a mortality of 22.6 per cent. The mortality would be materially lessened if all cases who died without operation were omitted from the mortality calculations, as twenty-five of the sixty deaths would be eliminated, making an operative mortality of 15.8 per cent.

TABLE II

Comparative Mortality

Number of Cases and Per Cent. of Deaths by Years

	Author: Brown [8]			Farr and Levine [9]			Steinke			Total		
Years	Cases	Deaths	Mort. Per Cent.	Cases	Deaths	Mort. Per Cent.	Cases	Deaths	Mort. Per Cent.	Cases	Deaths	Mort. Per Cent.
0- 1	22	9	41	15	10	66	31	22	71	66	41	60
1- 2	65	28	43	69	22	33	33	15	45	167	66	40
2- 3	55	12	22	63	17	27	30	9	30	148	38	26
3- 4	29	11	38	51	7	14	26	2	8	106	20	19
4- 5	33	4	12	39	7	18	33	2	6	105	13	12
5- 6	24	2	8	43	2	5	31	1	3	98	5	5
6- 7	17	1	6	32	3	9	31	5	16	80	9	11
7- 8	8	2	25	24	1	4	30	7	23	62	10	16
8- 9	6	0	0	10	1	10	21	0	0	37	1	3
9-12	8	2	25	16	1	6	19	4	21	43	7	16
12-15	0	0	0	9	0	0	25	3	12	34	3	9
Total	267	71	26.6	371	71	19.4	310	70	22.6	946	213	22.7

Death per cent. is in whole numbers.

Rib resection was the operation of choice, being performed either alone or preceded by aspiration in 256 (82.6 per cent.) of the 310 cases, with thirty-two deaths, a mortality of 12.5 per cent. There were twenty-three cases in which thoracentesis alone was performed, with ten deaths, a mortality of 43.5 per cent. The other types of operation are tabulated in Table III, but are too few in number from which to draw conclusions. Neither the packing of the empyema cavity with the gauze nor the tidal irrigation method of treatment was used.

TABLE III

Results Obtained by Various Types of Operations

	Total Cases	Not Improved	Improved	Cured	Deaths	Mortality Per Cent.
Rib resection	252	3	173	46	30	11.9
Thoracotomy, intercostal	3			1	2	66.6
Thoracentesis	23		12	1	10	43.5
Thoracentesis and resection	4			2	2	50
Drainage	3		2		1	33.3
None	24				24	100
Not stated	1				1	100
Total	310	3 (1 per cent.	187 (60.3 per cent.)	50 (16.1 per cent.)	70 (22.6)	

Improved in most cases means they were clinically cured but the wound was not completely healed on discharge from the hospital.

Complications account for many deaths and several deserve special mention. One patient had hydrocephalus and spina bifida; another had a lung abscess with pneumothorax; a third suffered from malnutrition from birth. None of these was operated. One child had complete intestinal obstruction

and died following jejunostomy. Another had erysipelas of the wound. Autopsy on another showed status lymphaticus. One had measles as a complication, and another otitis media. Cameron[6] reports that in every case where autopsy was obtained, complications were found. Rienhoff and Davison[7] found that the death-rate was twice as high with closed thoracotomy as when rib resection was performed. They believe that open thoracotomy in all infants under two years will give the best results. The younger the patient and the poorer his condition the more important it is to establish free drainage immediately. Brown[8] reported on 250 cases of empyema in children from 1906–1912. Of this number 171 were treated by resection, with a mortality of 21.5 per cent. Of the fifty-four treated by intercostal drainage, 40.3 per cent. died.

In Table IV the diseases which are given in the histories as being the forerunners of the empyema are listed. Of the 246 cases in which the predisposing disease is mentioned, pneumonia alone, or as a complication of some other disease, was present in 224 or 91 per cent. of cases where the predisposing condition was given, or 72.3 per cent. of all the cases. Pneumonia alone was present in 162 cases, or 65.8 per cent. of the 246. Thirty-two of the cases complained of pain in the chest, fever, cough or cold, which may have been pneumonia. Other predisposing causes or symptoms were, abscessed ears or earache in four, bronchitis in two, appendicitis uncomplicated in one and with abscess in one, and one case each of diphtheria, pleurisy complicated with measles, hydrocephalus, pectoral abscess, whooping-cough, and tonsillectomy.

TABLE IV

Diseases or Symptoms Preceding Empyema

	Number of Cases	Per Cent.
Pneumonia	123	39.7
Lobar pneumonia	16	5.2
Bronchopneumonia	23	7.4
Pneumonia as complication		
of influenza	8	2.6
of measles	11	3.6
of other diseases	11	3.6
Cold, fever, cough and pain (likely pneumonia)	32	10.3
Scarlet fever	3	1.0
Measles	5	1.6
Influenza	6	1.9
Foreign body	2	0.6
Pleurisy	5	1.6
Tuberculosis	1	0.3
Others	23	7.4
Not stated	41	13.2
Total	310	100.0

Total pneumonia, 224; 72.3 per cent. of all cases; 91 per cent. of cases where cause given.

A study of the deaths showed that when pneumonia was the predisposing disease, and where operation was performed without post-operative complication, and where symptoms had been present no more than two weeks, death ensued more quickly than when the disease had been present for a longer period.

TABLE V

Type of Organism Cultured and Relation to Result

Organism	Number	Per Cent. of 175	Improved	Cured	Deaths		
					No.	Per Cent.	Per Cent. of 175 cultured
Pneumococcus	121	69.5	75	28	18	14.9	10.3
Pneumococcus and staphylococcus	5	2.8	2	2	1	20.0	0.5
Pneumococcus and *Bacillus coli*	1	0.5	1				
Pneumococcus and *Bacillus influenza*	1	0.5	1				
Staphylococci	15	8.6	5	1	9	60.0	5.1
Streptococci	14	8.0	7	4	3	21.4	1.7
Bacillus influenza	1	0.5			1	100.0	
Other organisms	1	0.5			1	100.0	
No growth	16	9.1	14		2	12.5	1.1
Total	175	100.0	105	35	35		20.1

One case of pneumococcus where result is not known is not included.

Table V gives the relation of the organism cultured to the final result. There were 158 cases where the organism was identified either through culture or smear (usually the former), and sixteen others showed no growth. There were thirty-three deaths where the organism was known. In 121 (69.5 per cent.) of the 175 cases in whom cultures were taken the organism was a pure culture of pneumococcus, with a mortality of 14.9 per cent.; staphylococcus in fifteen cases, with a mortality of 60 per cent.; and streptococcus in fourteen, with a mortality of 21.4 per cent. Pneumococcus caused 51.4 per cent. of the thirty-five deaths where cultures were taken, staphylo-

TABLE VI

Comparative Study of Mortality in Each Organism Group

	Pneumococcus		Streptococcus		Staphylococcus		Mixed		No Growth	
	Cases	Deaths Per Cent.	Cases	Deaths Per Cent.	Cases	Deaths Per Cent.	Cases	Deaths Per Cent.	Cases	Deaths Per Cent.
Steinke	121	18 (14.9)	14	3 (21.4)	15	9 (60)	7	1 (14.3)	16	2 (12.5)
Farr and Levine[9]	73	18 (24.6)	23	6 (26)	6	4 (66)	12	5 (42)	20	6 (30)
Hudson[10]	52	6 (11.5)	16	3 (18.7)	6	1 (16.6)	5	1 (20)		
Ladd and Cutler[11]	160	25 (15.6)	35	10 (28.6)					36	8 (21)
*Rienhoff and Davison	26	8 (30.8)	4	4 (100)	8	3 (37.5)				
Total	432	75 (17+)	92	26 (28+)	35	17 (48+)	24	7 (29+)	72	16 (22+)

* (All under two years.)

Variable results may be due to mildness or severity of the epidemic or virulence of organism

coccus 25.7 per cent. and streptococcus 8.6 per cent. Table VI compares the causative organism with those of other authors.

Dr. Evarts Graham stresses the point that the mortalities of empyema and pneumonia run about parallel. Table VII shows the comparison over a ten-year period at the Children's Hospital. There is a great variation some years, but the mortality for the ten years is practically the same.

TABLE VII

Acute Empyema and Pneumonia Cases

Ten-year Mortality Contrast by Years

	Empyema			Pneumonia		
Years	Cases	Deaths	Mortality Per Cent.	Cases	Deaths	Mortality Per Cent.
1923	12	5	42	54	15	29
1924	12	4	33	49	11	22
1925	15	0	0	63	18	28
1926	16	3	19	74	19	25
1927	23	2	9	63	17	27
1928	39	5	13	127	43	33
1929	35	9	26	149	37	24
1930	16	7	44	87	27	31
1931	26	10	38	90	17	18
1932	23	9	39	104	20	19
Total	217	54	25	860	224	26

The average number of hospital days was twenty-five. The average number of days for cases which died was fifteen, for those who recovered twenty-eight. The shortest stay was a case which died in two hours following aspiration, and the longest stay was 102 days in whom rib resection was followed by cure. The longest duration of predisposing symptoms was six months in one case where the diagnosis had been tuberculosis. This patient was discharged ten days following rib resection and a cure resulted. Another case suffered from malnutrition for five months before entering the hospital, and died after operation. With these two exceptions, the longest duration of symptoms was two months.

The side involved and the mortality is given below.

	Cases		Deaths	
		Per Cent.		Per Cent.
Left	148	(47.8)	27	(18.2)
Right	136	(43.9)	31	(22.8)
Both sides	11	(3.5)	11	(100)
Not stated	15	(4.8)	1	(6.6)
Total	310	(100)	70	(22.6)

CONCLUSIONS

1. Study of a series of 310 cases gives a general mortality of 22.6 per cent. and an operative mortality of 15.8 per cent., which compares very favorably with that of other writers.

2. Rib resection alone gave the lowest mortality (11.9 per cent.).

3. The death-rate up to six months is by far the highest and the second six months next high. Open drainage should be employed early in young children.

4. The mortalities for pneumonia and empyema vary considerably in this series by years, but are practically the same over a ten-year period.

5. There were 186 males and 124 females.

6. Pneumonia was the predisposing cause in 91 per cent. of the cases where the cause was given and 72 per cent. of all cases.

7. Pure pneumococcus was grown from 69.5 per cent. and mixed in 4 per cent. of the cultured cases.

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THE FORMATION OF GALL-STONES

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The potentiality of the formation of concretions is inherent in all the body fluids, since they all contain, in solution or suspension, materials which, if the conditions of solution or suspension change, may fall out and mass together. The composition of the concretion will depend upon the nature of the particular body fluid from which it forms; the shape will depend upon the space in which it is contained. The organs whose products are carried through tubes to points outside the organ are most liable to concretion formation, since these products may encounter on their way conditions which change the chemical reactions so that precipitation may occur.

We find, therefore, concretions in the salivary ducts, in the pancreas, the prostate, the kidneys, ureters or urinary bladder. But most commonly they are encountered in the biliary tree, because here another factor enters, the appearance in the liver excretion of a material not found in other organ products, *i.e.*, cholesterol, which seems peculiarly liable to drop out of solution or suspension and to mass together to form a concretion. We, however, encounter among the so-called gall-stones examples of concretions quite comparable to those found in other organs, masses of salts or pigments, the inner structure of which concretions shows no regularity of arrangement.

Concretions of this type are perhaps no more commonly found in the bile passages than are their analogues in the urinary tract, and so far as we have ever seen, are the only gall-stones found in animals other than man. The great majority of human gall-stones are composed of cholesterol, with which bile-salts and bile-pigments may be associated in varying amounts; but the peculiar character of these cholesterol stones is determined by the sterol content, which, with its tendency to crystal formation out of what must have been a colloid state results in the usual type of human gall-stone.

It is a study of this common type of gall-stone which we wish to discuss here. These concretions present certain peculiarities of structure which we believe point to the manner of their origin and formation, and which lead to conclusions somewhat at variance with the commonly accepted ideas of gall-stone formation. Because gall-stones exhibit a radial arrangement of crystals, often apparently starting from a different material, such as a mass of bile-pigment, in the centre, which has been looked upon as a nucleus, it has long been assumed that such is the method of their formation. This belief is still held, in spite of various facts which have long been pointed out, which seem impossible of explanation on any such theory of formation. Not always is a nucleus to be found; indeed, many stones, immediately after removal from

the gall-bladder, and before any drying has occurred, are found to contain not a nucleus but an actual cavity, and now and then a stone is found in which this cavity is so large that the stone is rather comparable to an eggshell. The crystalline structure of a gall-stone shows that the large crystals are in the centre, while the small ones are at the periphery. In crystallization processes the small crystals are the ones first formed, the large ones last.

But it is useless to review the previous arguments; they are no more convincing today than they have been, these fifty years and more. Let us rather see if there is any new approach which might offer proof rather than argument.

In the diagram (Fig. 1) the relation of a crystalline structure to the external form of the object is schematized under two conditions, with the crystal growth starting from the centre and with the crystallization starting from the outside. If such a crystallization starts around a nucleus and grows equally in all directions, the result would be a radial arrangement of crystals, regardless of the form which external circumstances forced the finished product to take, as in the three forms shown, the circle, No. 1, the square, No. 2, or the triangle, No. 3. If the crystallization started at the periphery of a spherical mass and proceeded toward the centre, the result would be the same, No. 4, a radial arrangement, perhaps indistinguishable from the form which started from the centre. But if we leave out the round forms, and study the square and the triangle, we find that a product results when crystallization occurs from the outside toward the centre, Nos. 5 and 6, which is characteristic, and which could not occur were the crystallization proceeding from centre to periphery. In the circle a line perpendicular to every point of the periphery intersects the centre; crystallization follows a line perpendicular to the surface, and so the crystals in the circle radiate to the centre. But in the square or the triangle, the lines of crystallization, perpendicular to the surface, meet and conflict or stop at points which result in a typical internal figure, a figure brought out particularly if the crystals have pushed ahead of them into this area substances which may have been present in the original mass as impurities, or which are set free in the crystallization process.

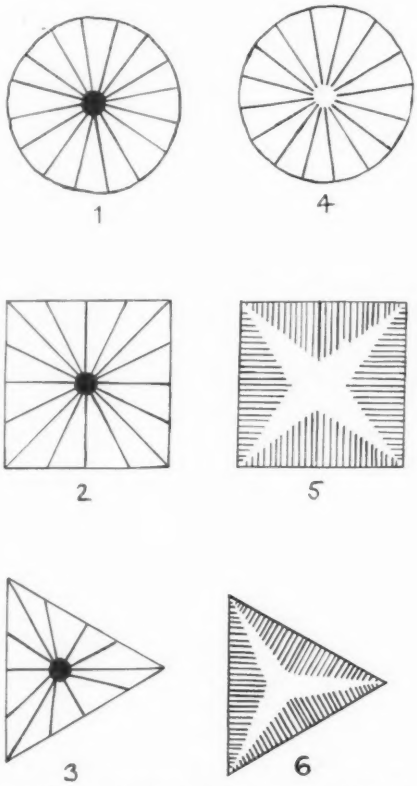

FIG. 1.—Schema of the cross-section of structures formed when crystallization proceeds from a nucleus toward the periphery (1, 2, 3), and when the crystals form from periphery toward the centre (4, 5, 6).

It is now a simple experiment for anyone to follow the building up of such a structure, by following the formation of the ice cubes in an electric refrigerator (Fig. 2) (though the separator which divides the freezing compartment into the cuboidal spaces must be of metal, not rubber). In this experiment, one can satisfy himself that the ice crystals first form along the bottom and the sides; and in the finished cube one can see how the air bubbles, set free from the water as crystallization progresses, are pushed into the areas toward the corners where the crystals coming from the sides meet, and into the centre; and one will find in the four rounded corners of the freezing com-

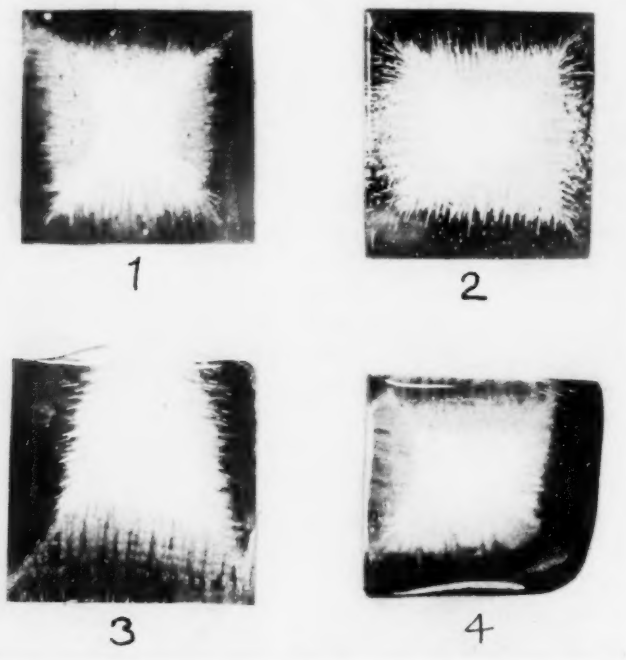

FIG. 2.—Ice cubes. 1 and 2 seen from above; 3 seen from the side, showing how the crystals have formed from the sides and the bottom of the container, toward the centre; 4, the cube from the compartment with one corner rounded, showing the difference between the rounded corner and a square corner.

partment (Fig. 2, No. 4) that this line of crystal conflict is not seen in the rounded corner, while it is present in the other three corners of the cube.

Thus since the arrangement of the crystals in the spheroidal stone could not, perhaps, offer positive proof of either the nuclear theory or the theory here presented, let us leave them out of consideration for the moment, and study the cuboidal and pyramidal gall-stones; here we find what is to us convincing proof that the crystal arrangement must have occurred from the outside toward the centre of a mass of the size and shape of the finished stone. In the stone with square cross-section (Fig. 3, Nos. 1 and 2) we see the same figure we find in the ice cubes, which we know form from the outside toward

the centre. In the stone of triangular section (Fig. 3, Nos. 3 and 4) this same meeting of the crystals results in a definite triangular pattern; and in all these gall-stones other than spheroids (Fig. 4, Nos. 1 to 8), we have always found such evidence in the angles of a process which starts at the periphery.

We do not wish to convey the idea that we believe this picture in the angles of the gall-stone is entirely due to the crystallization process, because our studies have led us to the feeling that the crystallization of the cholesterol

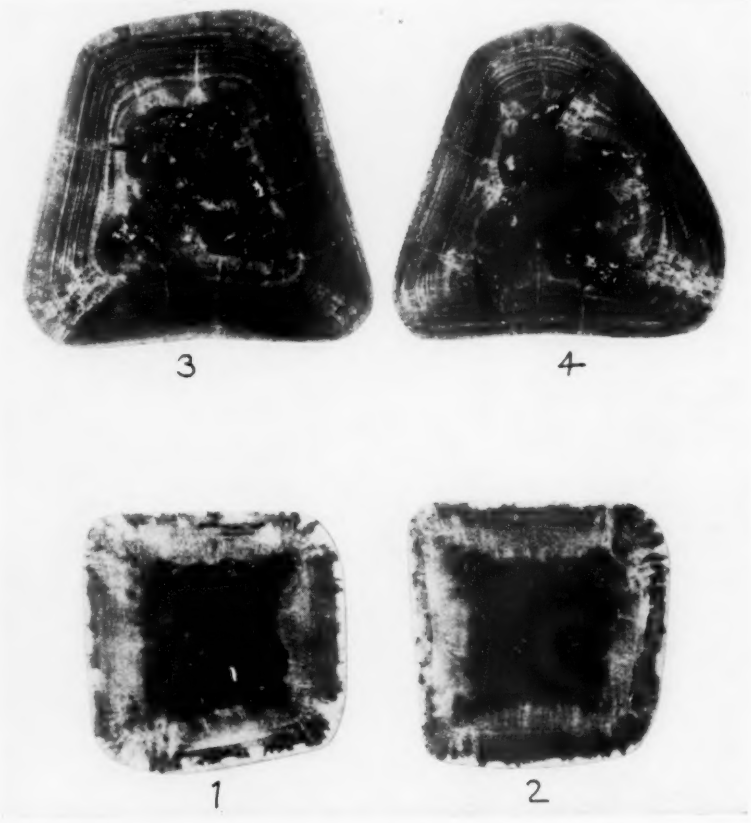

FIG. 3.—Internal structure of gall-stones of square cross-section, 1 and 2 (compare with Fig. 2, 1 and 2), and of stones of a roughly triangular cross-section (3 and 4).

takes place after another process has occurred which, however, starts also from the outside of the mass and proceeds toward the centre. This process follows the same law as crystal formation, following lines perpendicular to the surface, and results therefore in the same conflicts where the lines of force meet in the angles of the structure.

This is the phenomenon first described by Liesegang and called by his name, which is found when diffusion of a substance occurs into a colloidal mass containing a second substance which reacts with the outside material to form a visible precipitate. The classic example is the precipitation of silver

chromate, when silver nitrate diffuses into a gelatin mass containing potassium dichromate. The striking feature of this process is that the precipitate occurs in the form of lines or rings, separated by clear spaces.

Cholesterol stones often exhibit beautiful examples of such Liesegang rings, which in the past have been looked upon as evidence of layering or lamellation. As with crystal formation, so with diffusion, the event proceeds along lines perpendicular to the surface. As with crystal formation, so with this diffusion phenomenon, in a circle it is perhaps impossible to decide whether the process begins at the centre or at the periphery of a rounded mass (Fig. 5, No. 2). But in the irregular masses the same phenomenon appears with diffusion as with crystallization, the conflict of forces at the angles resulting in a characteristic picture.

If masses of dichromate gelatin are cut in the shape of gall-stones and

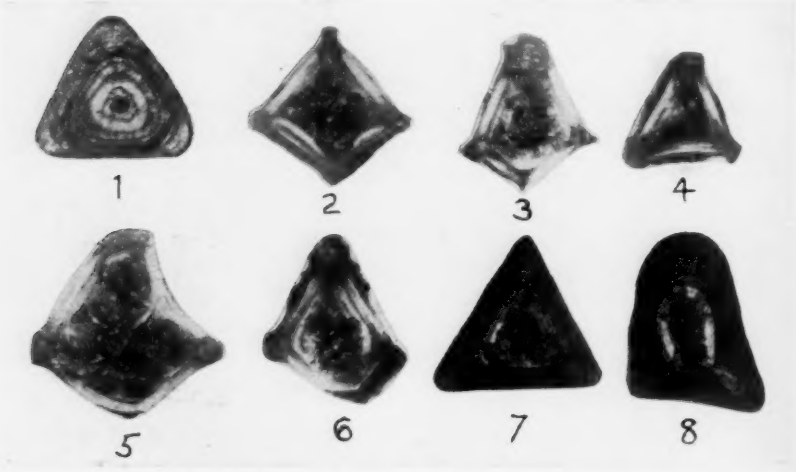

FIG. 4.—Cross-sections of gall-stones of various shapes, showing the effect of the angles on the internal structure.

dropped into a solution of silver nitrate, they will show on section such pictures as are seen in Fig. 5. These show the so-called lamellations of typical gall-stones, Nos. 1 2 and 4; they may show in the centre what would be called a nucleus, did we not know that the figure is the result of a process which started on the outside; and they may show in the angles a picture entirely comparable to the finding in gall-stones. (Compare Fig. 5, No. 3 with Fig. 3, Nos. 1 and 2.) In the gall-stone the reaction is between calcium and bilirubin or some of the oxidation products of bilirubin, forming the varicolored rings of calcium bilirubinate and its products.

It is our belief, then, that cholesterol stones, the typical human gall-stones, because of this internal evidence offered by the stones other than round in shape, must arise as colloidal masses of cholesterol and calcium, both in colloid state and mutually maintaining each the other in this colloid state. These masses are molded into shape by the space in which the material col-

lects, in the gall-bladder into spheroidal form, in the neck of the gall-bladder or in the pockets of the cystic duct formed by the leaflets of the valves of Heister,[1] into various shapes and sizes. The bilirubin of the surrounding bile diffuses into this mass, the calcium diffuses outward to meet it, and as they meet colored rings, with intervening spaces free of precipitate, are formed according to the laws which govern the Liesegang phenomenon. The double

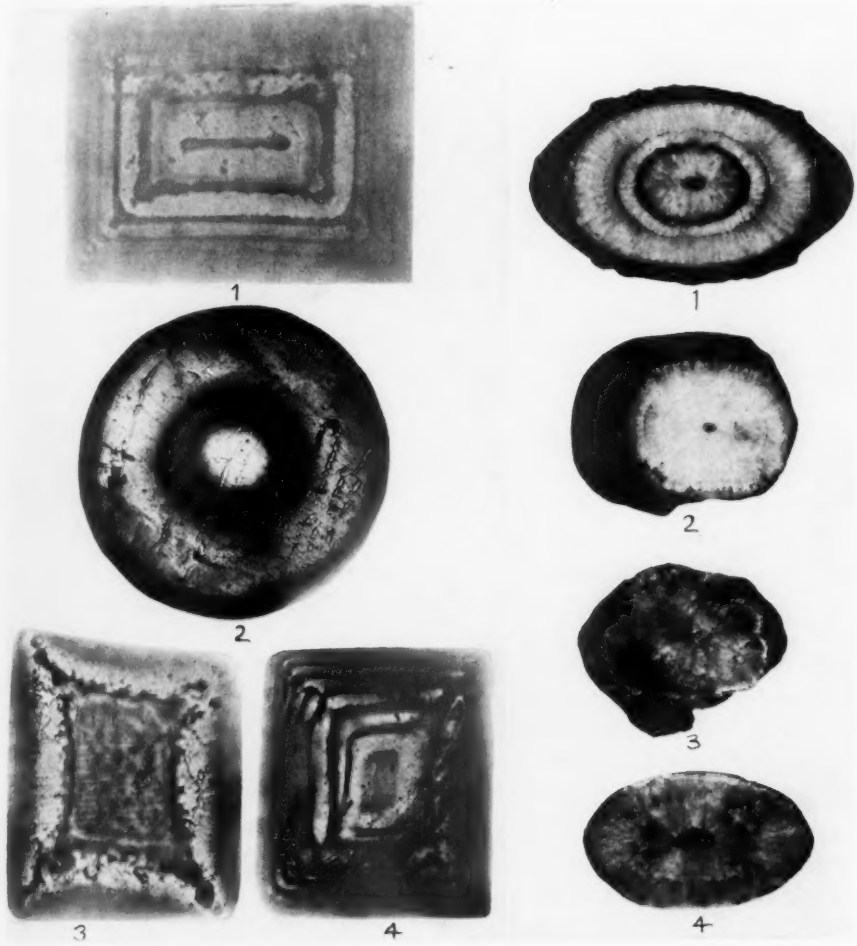

FIG. 5.—Cross-sections of masses of dichromate gelatin, after immersion in silver nitrate solution.
FIG. 6.—Gall-stones with the outer shell of calcium bilirubinate insoluble in the surrounding bile, 1, and soluble and partly removed, 2 and 3, and completely dissolved, 4.

or triple lines characteristic of the Liesegang process are formed; the lines are interrupted by impurities; and the result is an infinite variety. As the calcium diffuses away from the cholesterol, the cholesterol passes from the colloid to the crystalline state, crystallizing from the outside toward the centre.

In the silver nitrate, potassium dichromate, gelatin experiment, the surface of the mass is covered with a dense coating of silver chromate; in the

same way a dense precipitate of calcium bilirubinate forms on the exterior of the gall-stones. This outer shell of calcium bilirubinate may be insoluble in the surrounding bile and thus remain intact (Fig. 6, No. 1); or it may be soluble, and thus we have such stones as seen in Fig. 6, Nos. 2 and 3. Fig. 6, No. 3 was covered with soft mud, which could readily have been completely washed off, but dried to a hard mass; and, finally, if it is entirely dissolved off, we may have a pure cholesterol stone, No. 4, which is not a new or different thing, but simply the insoluble centre of a stone which was formed in the same fashion as those with an insoluble and therefore persisting, outer shell, No. 1.

Weiser[2] accepts these general principles of gall-stone formation, except that he would have the process taking place after the cholesterol has crystallized in a mass in which fibrin or albumen add the colloid element. He writes,[3] "In the first place, the gall-stone is probably not a true jelly at any stage of its history, as assumed by Sweet."[4] This is not exactly an assumption, since jellylike masses have been seen in cholelithiasis. Weiser says further, "And if it did possess a true jelly structure like that of gelatin, rhythmic bands could not form as a result of diffusion since the bile-pigments are in colloidal solution and so diffuse but little if at all."

It would seem difficult to explain the presence of the bile-pigments in the bile if they are not diffusible, since they cannot pass out of the liver-cell into the bile-stream except by diffusion through the cell-membrane. Furthermore, if the ability to pass through a dead membrane is a measure of diffusibility, it is difficult to explain the presence of non-diffusible material in the tissues surrounding the gall-bladder, as is to be seen in every autopsy in the bile staining of all the tissues in the neighborhood of the gall-bladder. Finally, Weiser[3] explains his own experiment as follows: "The colloidal bile-pigments diffuse into a mass of cholesterol crystals, hydrophilic colloids and lime and the calcium-bile-pigment complex is deposited in concentric bands."

What, then, is the pathogenesis of gall-stones? It is a disturbed metabolism of cholesterol, such as occurs in pregnancy, or as is associated with obesity, or seems to follow infections as of the appendix which secondarily involve the liver, or disturbances of metabolism; an understanding of which must await knowledge concerning the rôle played in the body by this peculiar substance. It is useless to ascribe cholelithiasis to infection alone, for any surgeon knows that gall-stones can be found in perfectly normal gall-bladders.

Is this the only way in which cholesterol containing stones can form? There are exceptions. One is shown in Fig. 7, No. 1, a stone which must have been built up by direct addition of crystals. The result is a structure so different as to constitute what is almost proof that the common stone must have an entirely different manner of origin. These stones are apparently very rare; we have seen only three in our collection.

A somewhat more common type of stone which must be formed by the confluence of smaller stones is shown in Fig. 7, No. 2. These stones are often found as small, discrete masses, yet even these are a combination of smaller

masses. These stones appear to me to form as butter forms in the churn. The smaller masses gradually coalesce into larger masses. These stones never show the large crystal plates seen in the ordinary gall-stones; the crystals are in needle form. They probably arise from combinations of cholesterol and fatty acids, and therefore the simile with butter in the churn may be accurate as well as apt. While not so uncommon as the stones resulting from direct crystal growth, these stones are comparatively rare. These stones must also be the result of a disturbance in the metabolism of this peculiar sub-

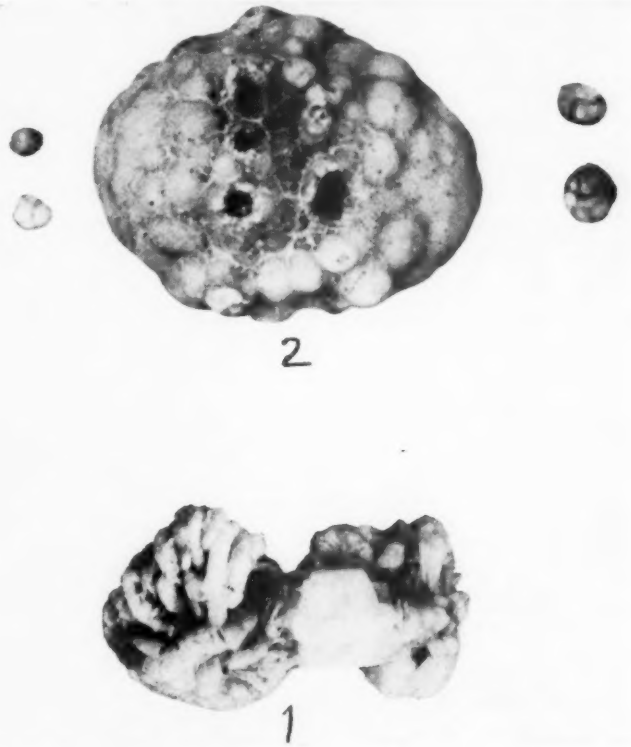

FIG. 7.—A gall-stone formed by direct crystal growth, 1, and by coalescence of smaller stones, 2.

stance, cholesterol, not the result of a cholangeitis, but a deeper lying upset of body function.

And how, then, does the removal of the gall-bladder cure cholelithiasis? Perhaps it does not influence at all this deeper lying disturbance. But it does remove the one-way street up which the stone-forming material travels but down which the stone cannot come. Cholecystectomy also helps by providing free drainage for the liver. One of the first effects of the loss of gall-bladder function, whether by disease or by the knife, is a dilatation of the extrahepatic ducts, which doubtless involves the papilla of Vater. Instead of a flow of bile into the intestine during the height of digestion, with back pressure into the liver and gall-bladder during the remainder of the day, bile flows

freely into the intestine as it is formed; in other words, free drainage is provided in place of the normal intermittent drainage. Whether the gall-stone-forming material stops forming under these conditions, or whether, as rapidly as it is formed, it is excreted into the bowel, where it does no harm, in either event no further gall-stones will form.

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COMPLICATED DISLOCATIONS

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An effort will be made to record a series of unusual experiences with dislocations in a few joints, first found in the cadaver and later in the living. No written records were made on the cadaver experiences at the time of the occurrence of each, largely because they happened so rarely and were unrelated to experience with similar dislocations in the living. A few dislocations *in vivo* did turn up later in each instance after the occurrence of the particular cadaver dislocation, and the observations made on the cadaver dislocations were of much value in the clinical cases. The first cadaver experience was with a posterior dislocation of the thumb at the metacarpophalangeal joint. After all obstacles to reduction had been removed except the torn capsule, it could not be reduced by any of several medical men present without cutting the capsule, and to preserve the specimen for the museum this was avoided. This cadaver experience occurred about 1899 and it was 1911 before the first similar dislocation in a living subject came into the writer's hands. The lesson taught by the cadaver dislocation indicated where and why the capsule could be best divided. An effort will be made to correlate a small cadaver and clinical experience obtained during the last thirty-five years.

Posterior Dislocation of the Hip.—Rare conditions are usually presented as individual case reports. Generalizations are hardly justified because of the scarcity of the case evidence. Dislocations are generally not obscure but a few are. The late O. H. Allis based his prize-winning monograph on dislocations of the hip upon the results of his efforts with cadaver dislocations to solve the obscurity associated with such a dislocation in a patient, which could not be reduced by some of the most prominent surgeons in Philadelphia at that time. His observations were presented in a clear and concise manner and from them came his method of reducing dislocations of the hip which, in the writer's opinion, is superior to any other. He concluded that, in the mysterious case which led him to make his studies, the failure to accomplish complete reduction by all who tried it was due to the hooking up of the great sciatic nerve by the head and neck of the femur in the sweeping movement resulting from the Bigelow method of reduction.

The writer became the assistant to the late Dr. G. G. Davis, when he became the head of the department of applied anatomy in the University of Pennsylvania in 1899. Doctor Allis was still engaged in his work on cadaver dislocations of the hip adjacent to the department of applied anatomy and Doctor Davis, while beginning his teaching of the anatomy of hip dislocations, was frequently in consultation with Doctor Allis. The writer became familiar with Doctor Allis' work by observation and conversation, assisted Doctor

Davis in making and dissecting many cadaver dislocations and later prepared many specimens for his own lectures. On two occasions only, during the thirty-five years, did he see a cadaver dislocation of the hip in which complete reduction could not be accomplished easily, and in these two it could not be accomplished by either of the two methods then in use, the Bigelow and Allis. Both specimens seemed to show all the signs found in the patient referred to by Allis, in whom so many surgeons had failed to complete the reduction. The first was obtained in a cadaver dislocation prepared for one of the lectures of the late J. William White, and was expected to be an ordinary type of posterior dislocation which could easily be completely reduced. In this specimen, however, the femoral head seemed to go back into the acetabulum, but the knee then remained in semiflexion and the surface of the popliteal space could not be brought into contact with the table. This was the special feature which attracted particular attention in the case which started Allis on his cadaver investigations. Some eight or ten years ago a second cadaver hip dislocation, produced for lecture purposes, behaved in the same way. It was placed in the vault for later dissection but by error was used for other purposes.

The first specimen was dissected and studied. The great sciatic nerve had not been hooked up by the femoral neck in the reduction, but lay where it belonged in the tissues. But a condition with which the writer had not been familiar had developed. In every other cadaver hip dislocation in the writer's memory the capsular ligament had torn away from the posterior acetabular margin retaining its attachment to the femur. The posterior portion of the capsule, therefore, followed the femoral neck in all its movements and could not interpose itself between the socket and the head in the reduction, and the reduction became easy and complete. In this rare specimen, on the other hand, when all the surrounding muscles and other tissues had been removed leaving the joint bones and capsular ligaments intact except for the dislocation and torn capsule, the femoral head was lying behind the acetabulum, and the torn posterior part of the capsule could not be seen. The reason was obvious; Dr. G. G. Davis was the first in the writer's experience to call attention to the fact that the capsule tear is never a longitudinal slit, but always a transverse one at right angles to the line of the tearing force applied. In this specimen it had torn transversely from its femoral attachment posteriorly, near the trochanters, instead of as usual from the acetabular attachment when the torn capsule cannot get in the way of the returning head. In this specimen this could not be avoided. The head could pass out of the joint only under the posterior torn margin of capsule detached from the femur below, when it would be behind the torn capsule which would then intervene as a curtain between the head and socket (Figs. 1 and 2). This would prevent complete reduction and the knee from coming down into complete extension.

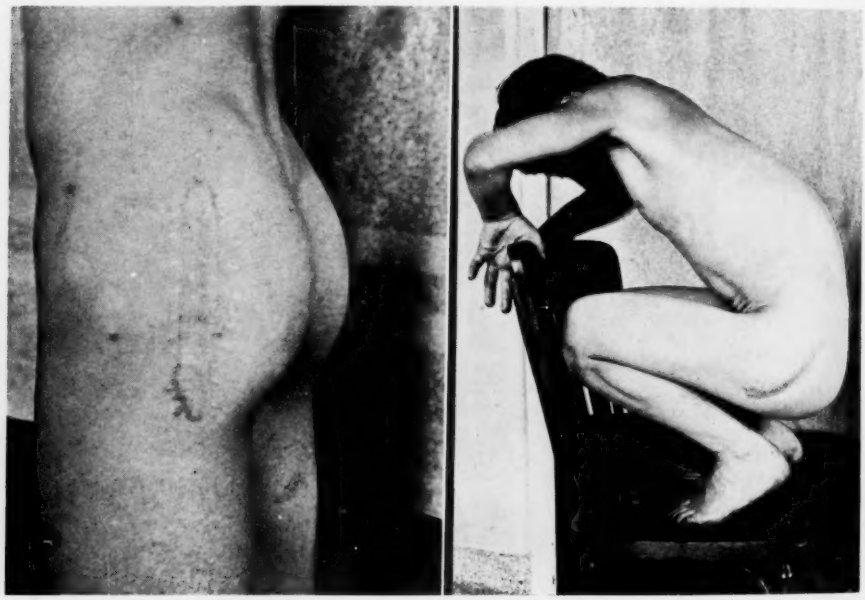
The most surprising finding was that the head could not be made to pass into the socket under the torn capsule margin because of the tension on this margin from side to side. It could not be relaxed enough by any manipula-

FIG. 1.—Cadaver posterior dislocation of hip. Note posterior capsule torn from attachment to femur and now pushed in front of head into acetabulum. It could not be disengaged from this position and brought over the head back to its normal position behind it except by grasping the torn edge at five points and then only in one position of rotation.

FIG. 2.—Cadaver posterior dislocation of hip. Posterior capsule detached from femur with the femoral head turned aside to show torn capsule lying in the acetabulum. There is some suggestion here of the small capsule opening through which the head escaped and must return into the socket.

tion. Even when the torn edge was grasped firmly by hæmostats at a number of points short distances apart, and all pulled on together, this edge could not be brought back over the head, and the efforts had to be abandoned. It seemed obvious that such a dislocation in life could not be reduced by any known method of closed reduction. Only such an open method would succeed that permitted division more or less at right angles of the tense capsule margin, to reduce the tension on it sufficiently to allow the femoral head to pass forward under it into the socket. The writer then and later wondered how he would proceed if the responsibility of such a dislocation ever occurred. It did appear twenty-five years after this cadaver experience with the following case:

CASE REPORT.—A boy, twelve years old, was admitted to the Northeastern Hospital, April 12, 1932, with a posterior dislocation of the hip. While playing handball he reached



A B

FIG. 3.—Shows scar of operation with hip functioning normally in, (A) Standing position. (B) Squatting position.

up to catch the ball and becoming unbalanced fell on his left side. At the same time one of his companions fell on him, after which he noticed severe pain in the region of the left hip and was unable to rise. X-rays taken promptly showed a posterior dislocation of the left hip-joint and he was taken to the operating room, etherized and efforts at reduction made by the Allis and Bigelow methods. The head of the femur was repeatedly placed in the acetabulum, but with the head reduced the knee could not be brought down in contact with the table, but persistently remained in flexion. After repeated attempts by other physicians present, complete reduction was not obtained, and the patient was returned to his bed and preparation ordered for open reduction on the following day.

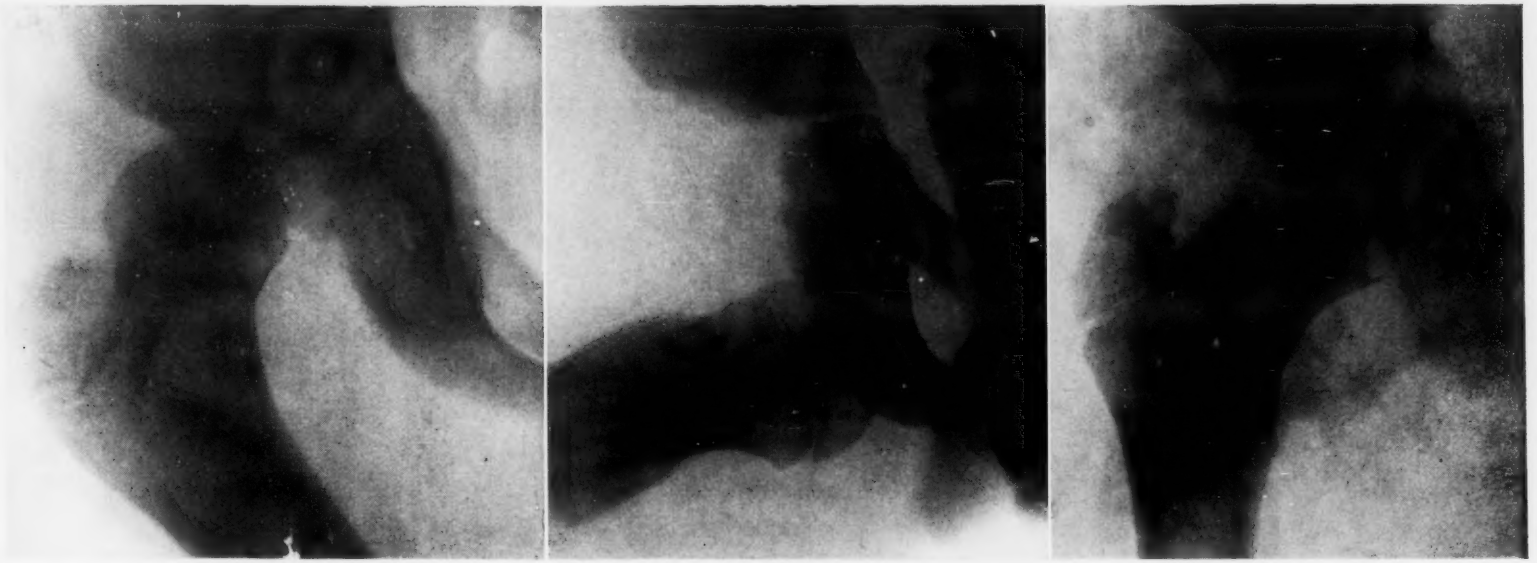
Operation, April 13, 1932.—With the patient on his right side partly prone and the hip in the flexed position, a longitudinal incision was made posteriorly and centred over

the dislocated head and tuberosity (Fig. 3). The skin and subcutaneous tissue were divided to the deep fascia and gluteus maximus, the fibres of which crossed the incision obliquely downward and outward. They were exposed widely on both sides and divided in the line of the fibres, exposing the greater tuberosity and insertion of the gluteus medius. This muscle was detached from the tuberosity outwards from its inner border about two inches in order to reach the acetabulum. The joint was now exposed sufficiently to introduce the finger into it, when it felt the transversly torn edge of the posterior capsule, which was now lying in front of the head. It was very tense, and was thickened where it joined the untorn portion or where the tear began at the side, due to its being doubled on itself by the inward turn.

With much difficulty this edge of the torn capsule was exposed at its outer limit and was divided as freely as possible about at right angles to the torn margin, thus

FIG. 4.—Showing posterior capsule detached from femur by posterior dislocation of hip back in its normal position and dislocation reduced. Note slight exposure of neck between torn capsule margins.

releasing much of the tension on the torn capsule edge. Manipulations now placed the head in the acetabulum positively, but the knee would not yet come down into full extension. The head was now dislocated anteriorly as much as possible, exposing the interior of the acetabulum, when it was seen that a portion of the capsule was still uncut; *i.e.*, the previous cut in it had not gone out to the periphery or edge of the acetabulum, so that the head in reduction still carried some of it into the joint. The existing cut just made in the capsule was extended out to the edge of the acetabulum after which the head went into the joint normally, and the knee came down into full extension. The posterior portion of the capsule which had been imprisoned in front of the head now lay posterior to the head and neck in its normal position, except for the slight separation of the incised margins made in it for the reduction (Fig. 4). No capsular sutures were used. There was very little hæmorrhage. The divided gluteus maximus was united with continuous catgut and the skin with interrupted silkworm gut.



A B C

FIG. 5.—X-rays of dislocated hip reduced by open method: (A) Before closed method of reduction failed. Note femoral head in usual position in posterior dislocation. It is lying behind the upper margin of the acetabulum. (B) After failure of closed reduction. Note femoral head lying below acetabulum. With the cadaver hip dislocation illustrated in Fig. 1, the head could be placed in the socket with the torn capsule intervening but could not be kept there without support of hand. (C) After open reduction.

Gauze dressing applied and adhesive plaster to hold it and support the wound. Patient turned on back and plaster case applied from the chest to the ankle to immobilize the wound with the limb in full extension. Placed in prone position in bed for twenty-four hours to avoid pressure on the wound. Healing uneventful. Discharged April 30, 1932. Patient rapidly recovered normal function which has continued to the present time (Fig. 5).

The following incident is of interest. At the time of the occurrence of the cadaver

FIG. 6.—Posterior dislocation of thumb (metacarpophalangeal joint). Note head uncovered by torn portion of capsule. (Concealed between head and base of phalanx.)

dislocation of the hip and its dissection with the failure of its reduction by the closed method, the writer reported at a meeting his experience with this unique specimen. Doctor Allis was present, and when the experience had been described up to relating the result of the dissection, Doctor Allis remarked: "You found the great sciatic nerve hooked up by the neck of the femur." Upon being told that was not the case, Doctor Allis said, "Then it was the capsule." He evidently had had both experiences.

Posterior Dislocation of the Thumb at the Metacarpophalangeal Joint.—Some of these dislocations are known to be very difficult of reduction by the closed method. They are easily reduced by the open method largely because the joint is easily exposed and the obstacle removed. There has been much discussion as to the nature of this obstacle. The writer has had only two patients with this dislocation, but he has made or had made many specimens on the cadaver for teaching purposes. Only one of these proved difficult of reduction by the closed method. That occurred some thirty-five years ago, and quite by accident; but the accident was never repeated. The writer had heard of different explanations for the causes of the difficulty in reduction. The one found in this specimen was the same as that revealed in the above cadaver dislocation of the hip-joint. Both joints are of the ball and socket variety, and all the dislocations in the thumb show the same capsular tear as was found in the related cadaver hip dislocation, *i.e.*, from the neck of the bone with the ball end, the proximal metacarpal in the thumb and the femur in the hip.

One day there occurred the above-mentioned cadaver dislocation of the thumb which resisted all efforts at reduction. Every other similar dislocation of the thumb made in the department before and since that time, so far as is known, presented no difficulty in the reduction, but this time persistent trials failed to reduce the dislocation. Dissection showed that the capsule had torn clean from the neck of the metacarpal bone (Fig. 6) anteriorly, and the torn margin had been dragged over the head of this bone under such tension that when the tense capsule edge passed over the head it slipped or sprang behind the neck and became imprisoned there. All the traction that could be applied was tried in the effort to bring that torn capsule edge forward over the rounded head to its normal place in front of the neck, without effect.

Case Report.—On May 9, 1912, a medical student, while wrestling, dislocated the metacarpophalangeal joint of the thumb posteriorly. He had done this on a number of other occasions, and had never any difficulty in accomplishing its reduction. He was then taken to the University Hospital where several internes in turn tried to reduce the dislocation with no success. The writer similarly failed and had the patient prepared for an open reduction. A longitudinal incision was made over the prominent head of the metacarpal. The tendon of the flexor longus pollicis with the inner wound margin was retracted to the inner side and the outer wound margin outward, exposing the glistening head uncovered by the anterior portion of the capsule, which should have covered it normally. It could not be seen because it was now behind the head, between it and the articular surface of the phalanx of the thumb, and it could not be dislodged from this position. A bistoury was inserted flatwise behind the head, between it and the capsule or glenoid ligament which was assumed to be there if not seen. The cutting edge of the bistoury was turned directly backward against the capsule and phalanx, cutting the ligament against the joint surface of the phalanx. The effect of the cutting of the capsule or ligament was such that its tense margin immediately relaxed, and the dislocation, without further effort, seemed to reduce itself spontaneously, and the divided ligament or capsule was seen to be lying in front of the head in its normal position. The wound was closed in the usual manner.

The cadaver dislocation of the thumb was encountered about seven to ten years before that of the hip, both of which were apparently impossible of reduction. The above opera-

tion on the patient with the corresponding thumb dislocation was done about twenty-one years before that on the patient with the hip dislocation that could not be reduced by the closed method. The latter operation was patterned after that of the thumb dislocation, because the problem was the same.

FRACTURE-DISLOCATION OF THE SHOULDER.—There is probably more obscurity associated with injuries of the shoulder joint than with any other joint. The writer believes that the most common cause of injuries here is hyperabduction of the arm, usually from falls on the hand. The usual end-result of severe hyperabduction when the skeleton gives way at the joint is an anterior or subcoracoid dislocation, never any other dislocation. The skeleton may give way above or below the joint by fracture when the joint usually remains intact, but fracture and dislocation may occur at the same time or in the same accident as in a fracture-dislocation. We are now interested in dislocations difficult of reduction and those of the shoulder generally are rarely difficult to reduce. The writer can recall only one uncomplicated dislocation of the shoulder that was difficult to reduce. The patient was an elderly woman on whom the physician in charge had failed repeatedly to accomplish reduction by the Kocher method. The writer, however, with the patient under ether anæsthesia, after trying the Kocher method without success exerted strong traction on the arm at right angles to the body with his foot in the axilla, the assistant pushing the head toward the socket. Several attempts of this kind failing, the force was increased with each effort and reduction was finally accomplished. The necessity for so much force in such a case was unusual in the writer's experience.

They are encountered only in fracture-dislocations, and not in all of them; there are many of these cases reported in the literature which have given much trouble. The decapitated head was usually said to be found under the coracoid process (according to the writer's experience it is further out), with its fractured surface looking outward or upward and outward. The lower fragment has usually been disengaged from the upper and lies in the vertical position with its upper end up under the acromion. The articular surface of the head is usually not far removed from the socket, but is not in it. These findings seem to the writer to be peculiar to the cases which prove difficult of reduction. The reduction of the dislocation and the fracture has been found impossible by the closed and the open method, and the attempt by the open method has frequently, if not usually, resulted in excision of the head.

The particular trouble has come from the efforts to mobilize the head without completely detaching it, after which it must be grafted in its normal place or removed. The writer has seen the X-ray films of a case in which the head was so detached and replaced as a graft. The surgeon who had operated on the patient reported a long, tedious delay in the process of union, without infection, the head having been much diminished in size by absorption and considerably deformed.

Probably few, if any, surgeons have had enough experience with these cases to justify an effort to explain why so many attempts at open reduction

have resulted in excisions of the head. Why should it prove so difficult to place the head in its normal place in the socket after an extensive wound is made to expose the joint by the deltopectoral route? These cases are so rare as to preclude effective study and analysis of one surgeon's personal cases. The writer has seen nine of these cases of fracture-dislocation in which open reduction was resorted to and one in which closed reduction was successful. Five of the nine cases operated on belonged to the type in which there was no particular difficulty in saving the head in accomplishing reduction, although in two of these the reduction of the fracture was not complete. In one the arm had been immobilized at the level of the shoulder for six weeks previously, permitting the abductor muscles attached to the upper fragment to become contracted, fixing it firmly in abduction. The writer immobilized the arm at the side, but could not bring the abducted upper fragment down sufficiently. In the other case, the upper fragment was comminuted though held together by its cartilage and periosteum, and was spread apart by the properly apposed lower fragment pulled strongly upward by the powerful muscles attached to it. Of the other four cases which like the thumb and hip dislocations could not be reduced by the closed method, and in which the open method usually led to excision of the head, two had been treated elsewhere for weeks and consequently were old dislocations and the other two were recent.

In the first of these two recent cases the incision was made between the deltoid and pectoralis major muscles. When the dislocated head was exposed it was uncovered by capsule and its white glistening cartilage came into view. This was the most arresting feature in the cadaver thumb and hip dislocations at first sight. The anterior portion of the capsule should have covered and more or less concealed them. The problem in each was the same; to find this part of the capsule behind the head in each and bring it forward to its normal position, which when done in each accomplished the reduction. While the surgeon was finding that he could not dislodge the head from its locked-in position the writer was searching for the evidence of the anterior part of the capsule which had disappeared from view, suspecting the problem was the same as in the cadaver thumb and hip dislocations. At the outer boundary of the exposed portion of the head and above was a thick firm bundle of tissue, which he interpreted to be the outer portion of the turned-in capsule where it joined the untorn portion which was preventing it from disappearing entirely from sight (Fig. 7). When the surgeon found that he could not dislodge the head, the writer asked if he would cut this band of tissue across completely; he immediately did so, and with a slight push on the head toward the socket the reduction was completed and the divided capsule lay in front of the head. This completed the analogy of cause and cure of these difficult dislocations of the thumb, hip and shoulder. The same capsule lesion was common to all three and the same treatment of the lesion accomplished the reduction in them all.

Not long afterward the same surgeon had another similar case in which

the writer assisted. Approach to the joint was made through the axilla and after getting to it could see nothing like the band of tissue he had divided in the preceding case. He could, however, introduce one or more fingers into the joint without seeing into it, and reported feeling a strong band of tissue crossing the joint which he thought he could divide safely. Guided by his finger, scissors divided this band of tissue after which the imprisoned head was easily pushed into the socket. In both of these cases the reduction of the dislocation was accompanied by the reduction of the fracture, and the after course normal.

These are the only two cases in which this capsular lesion was found by the writer and they were not his own. In eight other personal fracture-

FIG. 7.—Cadaver anterior dislocation of shoulder. Note capsule torn from attachment to humerus and now pushed backward by head into glenoid cavity. It could not be disengaged from this position and brought forward to its normal place in front of the head by anything resembling the Kocher method but could be with much difficulty by strong traction on the arm in abduction and pushing head toward the socket. Approximate line of incision of capsule in fracture—dislocation difficult of reduction.

dislocations of the shoulder the above phenon was not encountered. Of the eight, four were probably of the same type, so far as could be judged by the X-rays, which seem to show certain characteristics peculiar to this type, although one may not infer much from cases not proved by operative findings. In one case thought from the X-ray to be of this type, but classed above with those not difficult, the manipulations necessary in exposing the dislocation and fracture seem to have reduced the dislocation by the time the joint was exposed. In another case (Fig. 8), the dislocation and fracture were reduced by very powerful traction on the arm at right angles with the body and the foot against the scapula. This was repeated several times before success was attained when the traction seemed dangerously severe.

Perhaps an attempt should be made to justify the same cutting of the capsule edge in the above two cases as was done in the thumb and hip dislocations difficult of reduction. The writer had long been considering the possible similarity in pathology. The first suggestion probably came from a brief reference to *luxatio erecta* and *luxatio horizontalis* in Warren and Gould's *Text Book of Surgery* a few years after its publication in 1902. In the former dislocation of the shoulder the arm remains in a more or less vertical position and in the latter it falls and becomes fixed in abduction to about a right angle with the trunk. A few years later the writer had a patient who fell down a flight of steps and arose with severe pain in one shoulder and that arm fixed in elevation nearly vertical until he "joggled" it and it fell to his

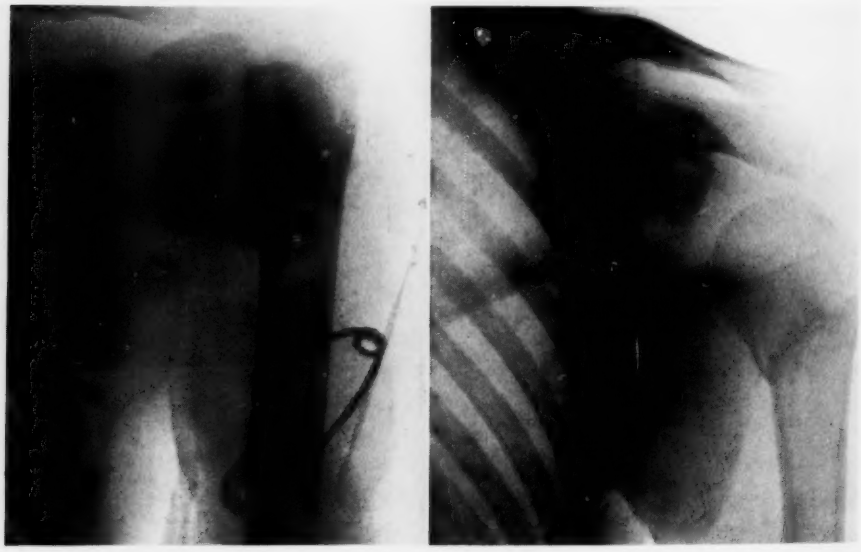


FIG. 8.—(A) Recent fracture—dislocation of humerus before successful reduction by closed method. Lower fragment in typical vertical position at side and upper end drawn up under acromion. Upper dislocated fragment so rotated that its fractured surface looks outward and upward. (B) After closed reduction. Separation of head from socket due to very severe traction which was largely maintained long enough to show its effect by the X-ray.

side. Only a dislocation, probably anterior, could have so fixed the arm in elevation. It was probably a *luxatio erecta*. Nothing seen in cadaver dislocations of this joint could account for this condition except the kind of fixation found in the above cadaver dislocations of the thumb and hip. The capsule tears almost always from the anterior glenoid margin. If it tore from the neck of the humerus, fixation of the arm in abduction might occur. It was such a thought that led to the suggestion to cut what might have been the outer end of the torn capsule turned back by the head in its effort to return to the socket and now intervening between the head and the socket.

Other evidence was afterward sought. The X-ray furnished some. The upper fragment appears to be fixed in abduction, the fractured surface looking outwards or upwards and outwards (Fig. 8). Such a capsule tear from

the humerus might hold it in this position and might prevent its reduction. In a *luxatio erecta*, fixed by the constricting edge of the torn portion of capsule against the influence of gravity, the leverage effect of the long heavy arm and the fulcrum effect of the obstructing capsule edge might cause a fracture of the humerus at the region of the fulcrum. While this may be the mechanism in most cases difficult of reduction it certainly is not in all cases. In many cases with this pathology of the difficult reductions, the reduction is probably possible by the closed method because of the short and shallow anatomical neck which probably does not catch the capsule edge as stubbornly as the long neck of the femur. Probably the best method is by powerful traction on the arm held in abduction in line with the upper fragment and direct pushing of the head toward the socket by an assistant. Counter-traction by the foot against the scapula is important. The writer has never failed to reduce by the closed or open method, usually with the latter, even in two old unreduced cases, although the open method was so severe that he now believes excision of the head is better. One of these two cases developed infection and ankylosis of the joint and the other died the following day from what was believed to be suppression of urine.

In the X-ray pictures of this condition the writer would emphasize (1) the abducted position of the upper fragment, for which an explanation has been offered; (2) the vertical position of the lower fragment with its upper end drawn up towards the acromion, because the upper fragment being held out of the way in abduction, the lower falls away from it to the side, so that there is nothing above to prevent its upward passage from muscle contraction; (3) the absence of bony obstruction between the head and glenoid process as in the common subcoracoid dislocation, their positions almost opposite each other and their comparatively slight separation. In the ordinary subcoracoid, when the head mounts over the obstruction of the anterior glenoid margin, it is pulled violently with a noise into its normal position. This suggests that in these cases something intervenes to keep the head out of the socket, probably the capsule.

In the first dislocation of the thumb which required open reduction, the previous similar dislocations had been reduced easily by the closed method. In the second thumb case, after repeated failure to reduce by the closed method, it was finally reduced by the closed method. The closed method was successful in one of the fracture-dislocations, probably having the same pathology as these difficult cases, but very severe traction on the arm was employed, probably more than most surgeons would care to risk. It was not tried in any succeeding case, the open method being considered safer. In the uncomplicated dislocation in the elderly female patient, the main factor in the reduction was the very strong and repeated traction on the arm. This was also true in the closed reduction of the second thumb dislocation. Doctor Allis, in connection with his demonstrations of cadaver dislocations of the hip, showed an apparatus of his own, devised for the reduction of very difficult hip dislocations, the only purpose of which was to make unusually

strong traction vertically on the femur, the main feature of his method of reduction. It permitted the use of the strong back muscles in the pull. Therefore in all of these difficult reductions, in the thumb, hip, and shoulder, the chief reliance was placed on traction. This is exerted on the untorn capsule at the two ends of the opening in the capsule through which the head escaped. It probably can draw the torn capsule edge back over the head in most cases, especially in the shoulder and thumb. In the hip, because of the long neck, it may be more difficult. If it fails, cutting the torn edge at right angles will probably increase the size of the opening and make reduction easy.

CADAVER REPRODUCTIONS OF SPECIAL CAPSULE LESIONS.

(See Figs. 1, 2, 4, 6 and 7.)

An attempt was made to imitate the special tearing of the capsule characteristic of these dislocations difficult of reduction in the hip and shoulder, that for the thumb being taken from the Museum of Applied Anatomy of the University of Pennsylvania. There is reason to believe that this is the specimen prepared from the one referred to in the beginning of this paper. These hip and shoulder specimens were made by an attempt to follow crudely the mechanisms employed in making dislocations of these joints in the cadaver except that instead of using only indirect force without any dissection the joint capsules were cleaned of the surrounding tissues. Then in applying the force to tear the capsule from the neck of the proximal bone and to prevent its tearing as usual from the margin of the cup, the capsule was detached from the neck of the bone in the middle of the desired tearing to start it properly and the tearing continued until the head of the bone was pried out of the joint under the torn capsule margin. This left the capsule intervening between the head and the socket.

ESSENTIAL HÆMATURIA

A CLINICAL AND PATHOLOGIC STUDY

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Idiopathic renal bleeding, otherwise known as essential hæmaturia, has for years constituted an etiological and clinical enigma. Despite numerous writings and considerable work on this subject, comprehensive uniformity of opinion is still lacking. Some urologists doubt the existence of this condition, and maintain that the diagnosis of essential hæmaturia in itself constitutes an admission of ignorance of the true cause of bleeding.[9, 10, 12, 13] Others believe that such a clinical entity does exist, and suggest various possible causes, such as renal ptosis, excessive renal mobility, nephritis, chronic passive congestion, abnormality of the circular muscle of the renal papillæ, inflammatory changes, and so forth.[4, 19, 20] Still others admit the diagnosis, and regard the underlying pathologic changes as either unknown or variable.[1, 2, 6, 14] Undoubtedly, prior to the development of present-day methods for investigation of the urinary tract, definite renal pathologic changes remained undetected in many cases of hæmaturia, and the diagnosis of idiopathic bleeding included a composite group of failures in diagnosis. Although at present many cases have been removed from this category, there are still certain cases of unexplained renal bleeding in which the diagnosis of essential hæmaturia seems not only entirely justified but definitely indicated.

The study reported here is a review of the clinical records of 100 consecutive cases from The Mayo Clinic, in which the diagnosis was essential hæmaturia, and a histologic study of ten kidneys removed because of this condition. All but one of these kidneys was removed more than ten years ago when methods of urologic diagnosis were less accurate than now, and the possibility of neoplasm could not definitely be excluded. The etiology, symptoms, diagnosis, pathologic changes, prognosis, and treatment are considered.

Etiology.—As emphasized by Braasch, in 1926, in all likelihood no single factor is responsible for the occurrence of essential hæmaturia. Despite this, there is a tendency among those who admit the existence of the disease to advance some single theory as an etiologic explanation of the condition. These theories have varied as widely as the range of theoretic possibilities permits, but, for the most part, they remain unsubstantiated. The obvious conclusion is that the exact cause or causes of this condition remain undetermined. The question of etiology may be considered from a clinical and pathologic point of view.

Similar to reports of other authors, there was a preponderance of males (74 per cent.) in our series of 100 cases. No particular age group was involved, as the ages ranged from twelve to seventy years, the average age being forty-five years. A certain number of patients (10 per cent.) stated that hæmaturia was aggravated by strenuous physical activity or muscular strain. Some patients (5 per cent.) related the onset of hæmaturia to minor trauma, which seemed insufficient to cause appreciable renal injury. Bleeding occurred an equal number of times from each kidney, and in no instance was abnormal mobility, congenital anomaly, or abnormal position of the bleeding kidney noted.

That infection may play an important part in some cases of essential hæmaturia seems clearly indicated by clinical data. In 14 per cent. of cases, the onset of bleeding was directly related to an acute infection of the upper part of the respiratory tract, most commonly influenza or tonsillitis. In 78 per cent. of cases there was definite evidence of dental or tonsillar infection at the time the patients were examined at the clinic, whereas in a control group of 250 cases there was evidence of tonsillar or dental infection in 57.4 per cent. (Table I). A history of acute infection of the upper part of the respiratory tract, or a demonstrable focus of infection in the mouth or throat was present in all but nine cases. The exact manner in which focal infection might be responsible for essential hæmaturia remains obscure. A series of careful experiments with the establishment of a chronic focus of infection in dogs might elucidate this question. Certain cases emphasize the possible significance of focal infection in the perpetuation or recurrence of bleeding.

TABLE I

Incidence of Dental and Tonsillar Infection in 100 Cases of Essential Hæmaturia

	100 Cases of Essential Hæmaturia, Per Cent.	Control Group of 250 Consecutive Admissions, Per Cent.
Infected teeth and tonsils	41	24
Infected teeth only	18	21
Infected tonsils only	19	12.4
Totals	78	57.4
Tonsils and teeth not examined	13	16

CASE I.—A man, aged twenty-eight years, first registered at the clinic in February, 1926, with the complaint of intermittent hæmaturia for one year. General and urologic examinations gave essentially negative results. As hæmaturia was not present at that time, treatment was not given. Hæmaturia occurred a few months after he returned home, and the bleeding was found to come from the right kidney. At exploration by an excellent surgeon elsewhere, the right kidney appeared entirely normal grossly. A few small vessels were ligated and the incision was closed. Bleeding recurred four months later and remained constant. The patient returned to the clinic some time later and urologic investigation at this time again gave entirely negative results, except that right

renal hæmaturia was found. Infected tonsils and several devitalized teeth were discovered. Tonsillectomy was performed July 9, 1928. For two days following removal of the tonsils, the bleeding was aggravated and then stopped entirely for the first time in two years.

CASE II.—A Mexican girl, aged fourteen years, came to the clinic April 11, 1925, with the complaint of intermittent hæmaturia. This had first been noted July 24, 1924, at a time when the patient had a sore throat. Hæmaturia returned again for a few days in September, 1924. In December, 1924, bleeding recurred, when the patient had measles and a sore throat. In January, 1925, bleeding again occurred when the patient had acute tonsillitis. Examination was entirely negative except for the infected tonsils and erythrocytes in the urine from the left kidney. Tonsillectomy was performed April 27, 1925, and although we do not have a late follow-up report on this patient, to our knowledge bleeding has not recurred.

Cases similar to these are sufficiently common to impress us with the significance of chronic focal infection as a factor in many cases of essential hæmaturia.

There has been dispute as to whether essential hæmaturia is primarily a local renal or a general disease. Although this question might appear rather futile, nevertheless, if the answer were known, a more accurate appreciation of the etiology of this condition might be available. Although bleeding may cease, at least temporarily, following lavage of the renal pelvis, this does not necessarily indicate the local nature of the disease. Bleeding may occur from both kidneys at the same time, or may change from one to the other, as occurred in 12 per cent. of the cases reviewed.

Symptoms.—Although patients complaining of hæmaturia do not present clinical histories which are definitely diagnostic of essential hæmaturia, in certain cases suspicion of the true diagnosis is aroused by the type and course of the bleeding. If intermittent hæmaturia occurs over a period of several years in the absence of other symptoms and impairment of general health, the diagnosis of essential hæmaturia is suggested. Naturally, if the patient is seen early in the course of the disease, perhaps in the first episode of bleeding, there is nothing in the history to suggest the cause of bleeding. In 33 per cent. of the 100 cases in this series the patients were seen within six months after the onset of bleeding, whereas in an additional 26 per cent. the patients were not seen until five to thirty-three years after bleeding first had occurred.

Typically, hæmaturia is intermittent, and individual episodes of bleeding vary considerably in length. In the present series of cases, periods of bleeding usually ranged from one day to two weeks in 31 per cent. of cases, from two weeks to one month in 29 per cent., from one month to six weeks in 23 per cent., and from six months to five years in 17 per cent. We say these periods of bleeding "usually" were of a certain length, as in each individual case consecutive episodes of bleeding commonly varied in duration, and in approximately a third of the cases subsequent attacks of hæmaturia were longer than the initial attack.

Bleeding in essential hæmaturia is not always painless. Mild pain over

the region of the bleeding kidney was occasionally present (8 per cent.) and pain suggesting renal colic also occurred (13 per cent.). The latter type of pain presumably exemplified so-called "clot colic," and was sometimes definitely known to be associated with the passage of blood-clots. There was no evidence of calculus in any case.

Diagnosis.—Even if the diagnosis of essential hæmaturia is one of exclusion, made only after careful investigation for any organic lesion that might be responsible for bleeding, nevertheless it can be made with a high degree of accuracy if certain general principles are adhered to. This statement is substantiated by the fact that to our knowledge during a period of five to twenty-five years, only two of the 100 patients subsequently had other lesions of the genito-urinary tract which might have been responsible for the hæmaturia at the time of the original examination. This represents a diagnostic accuracy of 98 per cent., which compares favorably with the accuracy of recognition of any other disease.

The diagnosis of essential hæmaturia requires careful cysto-urethroscopic examination which permits definite exclusion of neoplasm, calculus, diverticulum, inflammatory disease, or any other pathologic change which might be responsible for bleeding from the lower part of the urinary tract. In addition, there must be normal function of both kidneys and uninfected urine from both sides. Usually only one kidney is bleeding at the time of examination and a normal retrograde pyelogram should be obtained on this side. If hæmaturia is not present at the time of examination, bilateral retrograde pyelograms should be normal. A physician is not justified in depending on intravenous urography to exclude small defects in the upper part of the urinary tract, as, frequently, visualization may be inadequate for the discrimination of small variations from normal. When complete investigation of the urinary tract has revealed no abnormality, essential hæmaturia may be suspected, particularly if the clinical history likewise suggests this diagnosis. To obviate the possibility of error, however, it is always important to request reëxamination in six to twelve months. If a tumor existed but remained undetected during the original examination, it should have enlarged sufficiently to render detection certain following this interval. If the second examination is likewise negative, the diagnosis of essential hæmaturia is probably correct.

The general physical condition of patients with essential hæmaturia is rarely abnormal, although evidence of focal infection is often observed. Laboratory studies of the blood may sometimes reveal slight abnormalities. A moderate degree of anæmia may be present (22 per cent. of cases). In some instances the platelet count has been reported to be slightly subnormal, although the bleeding time and coagulation time of the blood are most commonly well within normal limits.[5] There is usually no familial or personal history of unusual bleeding.

Pathological Changes.—Essential hæmaturia is a clinical and not a pathologic diagnosis, and one might therefore not expect to find in every case

similar pathologic changes responsible for the bleeding. This in part explains some of the discrepancies noted in the literature in regard to many of the clinical and pathologic features of this condition. Another discrepancy has been caused by the failure of the clinician in some cases to exclude the presence of a definite cause for bleeding, such as neoplasm of the renal pelvis.

A review of the literature reveals descriptions of a multiplicity of lesions and occasionally no lesion in cases of essential hæmaturia. Almost all pathologic changes which may occur in the kidney and renal pelvis have been regarded as possible significant etiologic factors in this disease. In large

FIG. 1.—Tip of renal papilla. Numerous dilated venules filled with blood, and slight chronic inflammatory reaction beneath pelvic epithelium to the right (x30).

FIG. 2.—Tip of renal papilla revealing a large, dilated venule filled with blood (interstitial hæmorrhage). Proximity of the vessels to the overlying epithelium (x60). The kidney was a different one from those represented in Figs. 1 or 3.

part, most of these changes may be grouped as: (1) Changes in the papillæ or pelvis; (2) various forms and types of "nephritis," and (3) changes in the blood-vessels of the kidney, particularly those producing congestion.

Changes in the Papillæ or Pelvis.—Vascular changes in the papillæ of the kidney as a cause of essential hæmaturia were stressed as early as 1903 by Fenwick, and subsequently emphasized by Cabot in 1909. Fenwick applied the term "angioma in capillary nævus of a renal papilla," while Cabot wrote of a "varix papillæ." Since that time a variety of lesions in the papillæ have been described as causative factors of bleeding. The outstanding pathologic changes which have been noted are those of acute and chronic inflammation or papillitis and pyelitis, vascular dilatation, congestion, interstitial hæmorrhage, and lastly, variable increase of connective tissue with formation

of scar tissue. Occasionally, multiple microscopic calculi of the papillæ have been found associated with these lesions. Case reports such as those of Whitney, MacGowan, and Quinby emphasize the importance of papillary lesions. More recently, Wheeler (1930) has studied five cases at the Massachusetts General Hospital in which the outstanding changes were marked injection of the blood-vessels of the apexes of the pyramids not infrequently associated with interstitial hæmorrhage, moderate or extensive inflammatory reaction and fibrosis of the papillæ, pelvis, or pelvic fat. The appearance of the lesions suggested that they were of variable duration. There was involvement of all or only one papilla of the affected kidney.

Hæmorrhagic and chronic inflammatory lesions of the papillæ and the adjacent pelvis are the most commonly described lesions in the cases of essential hæmaturia reported in the literature. The etiologic factors underlying their development and the method by which such lesions produce intermittent or continuous bleeding are points of disagreement, and theoretic considerations in regard to them have been discussed by Rathbun, Payne and MacNider, and others.

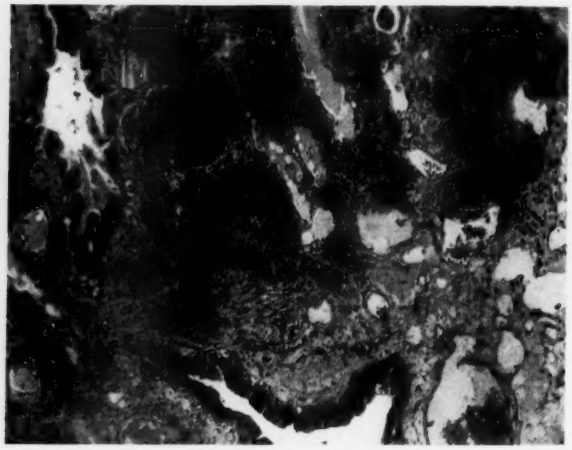

FIG. 3.—From another kidney. Renal papilla. Large dilated venules, interstitial hæmorrhage and fibrosis (x100). The kidney was a different one from those represented in Figs. 1 or 2.

Various Forms and Types of "Nephritis."—Focal nephritis, mild chronic glomerular or hæmorrhagic nephritis, unilateral glomerular nephritis, chronic pyelonephritis, and chronic interstitial nephritis, are among the lesions ascribed by some as causative factors of essential hæmaturia. These terms have too often been used loosely to interpret the presence of almost any type of change: inflammatory, sclerotic, or degenerative, in the renal cortex. The presence of an occasional fibrosed glomerulus, occasional scattered collections of lymphocytes, and of variable amounts of coagulated albumin in the capsular or tubular spaces has been interpreted as evidence of nephritis, whereas in fact such changes are not uncommonly observed in apparently normal kidneys, or in cases in which there is healed slight pyelonephritis or moderate arteriosclerotic change. The absence of changes considered to be characteristic of chronic glomerular nephritis, the unilaterality of the bleeding in most instances, and the long duration of the disease without the development of evident nephritis or renal insufficiency all suggest that essential hæmaturia is not caused by nephritic changes as these are interpreted today, and that therefore it is not a form of chronic nephritis or Bright's disease. Theoretic considerations strongly suggest that chronic glomerular nephritis is not an

etiologic factor in cases of essential hæmaturia. Braasch has emphasized this point, and noted: "It is very questionable whether true nephritis is a common etiologic factor. In a review of our cases of essential hematuria made several years ago we failed to find evidence of the usual forms of nephritis appearing later on. Certainly the patients did not die the death of nephritis."

Changes in the Blood-vessels of the Kidney, Particularly Those Producing Congestion.—A variety of vascular lesions, including arteriosclerotic changes, disturbances of the vasomotor nerves, angioneurosis, infarctions, aberrant renal vessels, venous stasis, ptosis of the kidney, and other factors producing congestion, have been interpreted as the underlying pathologic change leading to essential hæmaturia. The presence of some of these lesions cannot be denied in kidneys removed because of bleeding which clinically simulated that of essential hæmaturia. However, the lack of uniformity of findings in such cases, the frequent occurrence of essential hæmaturia among young persons who have minimal sclerotic changes, the frequent finding of aberrant vessels, the advanced sclerotic changes in the absence of bleeding, and the failure of the history of bleeding to agree with the clinical features produced by these changes militates against such an explanation in the majority of cases. Any factors producing circulatory change of sufficient degree to interfere with the venous return from the kidney might readily precipitate or increase bleeding from a lesion in the kidney. It does not seem reasonable that these factors alone would be responsible for intermittent bleeding, often of a month's duration, at intervals of many years.

Occasionally, cases are reported in the literature in which histologic study of the kidney removed for essential hæmaturia has not disclosed anything abnormal. This may be because the whole kidney was not studied; not infrequently, during an operation, a specimen of tissue from the cortex only has been removed. Reports such as that of Levy, in which the kidney removed had normal tissue histologically, except for engorgement, suggest that occasionally distinct pathologic changes are absent. It must be recalled that systemic conditions, such as blood dyscrasias and circulatory failure, may be factors precipitating or prolonging bleeding from a kidney.

A miscellaneous group of pathologic changes in the urinary tract has been described by some investigators as factors responsible for essential hæmaturia. These changes include cyst of the kidney, ureteral stricture, and rupture of arterioles in the bladder.

Pathologic Changes Observed in the Present Series.—The present observations were made on a series of ten kidneys, nine of which were removed surgically, and one of which was obtained at post-mortem examination. In each case clinical diagnosis was essential hæmaturia. Careful study was made of the cortex, including the glomeruli, tubules, vessels, and interstitial tissue, the corticomedullary juncture, the pyramids, papillæ, and pelvis. Changes of variable degree were noted in each case. The majority of them were in the papillæ and adjacent pelvic tissue.

Cortex.—The cortical portions of the kidneys were not distinctly abnormal. Evidence of chronic glomerular nephritis was entirely lacking. Since the ten patients from whom specimens were obtained were more than fifty years of age, moderate thickening of the vessels was frequently observed. In addition, collections of lymphocytes near the sclerosed glomeruli, or small areas of scar tissue, were not uncommon. Such changes are not unusual in "normal" kidneys of persons of this age. Variable amounts of increase in connective tissue occurring diffusely or in patches were noted in some kidneys.

The glomeruli appeared essentially normal except for occasional areas of thickening of the basement membrane, interpreted as the result of senile or arteriosclerotic change. Coagulated albumin was noted in some of the capsular spaces and hyaline casts were observed in scattered convoluted tubules. The convoluted tubules appeared normal or presented slight degenerative changes. In one kidney there was evidence of an old infarct in the cortex.

Medulla (Exclusive of the Papillæ).—The portion of the medulla comprising all but the tip of the pyramid was essentially normal in most of these ten kidneys. Various amounts of increased connective tissue, generally commensurate with the age of the patient, were observed. This thickening of connective tissue occurred diffusely or in patches and often presented hyaline changes. In addition, in some areas the intertubular capillaries were filled with blood. Evidence of chronic inflammatory reaction was not observed.

Papillæ and Adjacent Pelvic Tissue.—In every instance changes were noted in the tips of the papillæ, beneath the pelvic epithelium covering the papillæ, in the angle formed by the papillæ and pelvis, or in the submucosa of the nearby pelvic tissue. The changes were variable in degree, extent, and type, but they could all be grouped as: (1) Vascular or hæmorrhagic, (2) acute or chronic inflammatory, and (3) fibrotic.

Vascular Changes.—In practically every instance dilated blood-vessels could be demonstrated at the tip of the papillæ or beneath the surrounding epithelium. Most of the dilated vessels were thin-walled venules or capillaries either filled with blood, or empty. Hæmorrhage into the surrounding interstitial tissue was often associated. In a few instances recent hæmorrhage of considerable extent was present, whereas in others only small areas of submucosal hæmorrhage could be demonstrated (Figs. 1, 2 and 3). Numerous erythrocytes were present in the collecting tubules in the tips of some of the papillæ in association with the dilated, blood-filled vessels.

Inflammatory Changes.—Except in two instances, chronic inflammatory changes were not prominent. The inflammatory reactions consisted of collections of lymphocytes in the tips of the papillæ beneath the adjacent epithelium or in the submucosa of the pelvis. They were not infrequently associated with dilated vessels or hæmorrhagic areas. In one kidney which had been decapsulated and in another in which nephrotomy had been performed several days before nephrectomy, acute inflammatory changes were noted throughout the entire kidney. These changes were interpreted as recent, and not as

pathologic changes which were responsible for years of intermittent hæmaturia.

Fibrosis and Increase of Connective Tissue.—In the kidney, as in most organs, the amount of connective tissue advances with age. This is particularly true of the medullary portion, and among older patients there is often densely thickened connective tissue in the papillæ. This increase may be patchy or diffuse, and may be associated with hyaline change. It is difficult to estimate whether the amount of such thickening in the papillæ of a given kidney is normal or abnormal. However, in several of the cases in this series, the dense connective tissue either in the papillæ or beneath the epithelium of the associated pelvic structures indicated definite abnormality. Deposits of calcium were noted in the interstitial tissue at the tips of the papillæ in several cases.

The occurrence of fibrous tissue in association with dilated vessels and interstitial hæmorrhage suggests a relationship between the two, and, as emphasized by Rathbun, such formation of scar tissue may interfere with the flow of blood through these vessels. Certainly it must interfere with the flexibility of the vessels, and the response of the tissue and vessels to variations in both intrapelvic and vascular pressure.

Prognosis.—With rare exceptions, the prognosis in cases of essential hæmaturia is good. Although bleeding may be very resistant to local treatment in some cases, arrest of hæmorrhage may be anticipated in a very high percentage of cases if all foci of infection are eliminated. At present, nephrectomy is rarely advisable. Formerly, when one kidney was removed for this type of bleeding, hæmorrhage from the other kidney occasionally developed, but fatalities from this disease are practically unknown.

Treatment.—Accurate evaluation of the efficacy of various forms of treatment for essential hæmaturia is rendered difficult because of the well-known intermittency of the disease. As the episodes of hæmaturia frequently persist only for a few days or a few weeks, even if no treatment is given, it is obvious that any type of treatment may be credited with unwarranted value if continued until a natural remission ensues. Consequently, many different types of treatment, both local and general, have been advised.

Probably the most popular type of local treatment is pelvic lavage of the bleeding kidney with a solution of silver nitrate, 1 to 5 per cent. In our series of cases, this treatment was employed either with or without other forms of therapy in more than half of the cases, and bleeding stopped in more than 81 per cent. of the cases. Repeated lavage may be necessary before bleeding ceases; however, often a single application of silver nitrate is followed by complete cessation of hæmaturia. Other types of treatment, such as deep Röntgen therapy,[11] diathermy, pelvic lavage with epinephrine and other solutions have been used less frequently, and, in very exceptional cases, some type of operative procedure has been performed. In the ten cases in which nephrectomy was performed, bleeding occurred subsequently from the opposite kidney in two. Fortunately, this was not particularly severe and was

readily controlled. In our experience conservative surgical procedures have not proved to be of value in any case. Surgical procedures in any form are not advocated for these patients unless bleeding is so severe that the patient's life is jeopardized. Likewise, Röntgen-rays and diathermy have been employed in only a few of the cases in which the condition was resistant to other forms of treatment, and an accurate appreciation of their efficacy is difficult to ascertain.[8]

The most important single factor in avoiding recurrence of bleeding appears to be complete eradication of focal infection. Although satisfactory immediate results are usually secured by lavage of the renal pelvis with solution of silver nitrate, subsequent bleeding may be anticipated in approximately 70 per cent. of cases unless all such foci are removed. If known sources of infection are eradicated, there is much less chance of recurrence. The exact manner in which foci of infection may promote essential hæmaturia remains obscure; however, the clinical association between the two appears definite. This opinion coincides with the experience of others.[16] Intramuscular injections of whole blood, taken from the patient, are used frequently and may be of some value. Oral medication does not seem to be of value.

COMMENT.—Essential hæmaturia is a clinical diagnosis which in the past often has been made indiscriminately in cases in which bleeding could not be readily explained on the basis of obvious pathologic changes in the urinary tract. It has been loosely applied, perhaps, to a variety of cases in which the diagnosis was an enigma. Consequently, before the development of current diagnostic methods, or because of inadequate investigation or failure to reinvestigate after a period of several months, errors in diagnosis have occurred and caused confusion in discussions of the etiology and pathogenesis of essential hæmaturia. As a result, this diagnosis naturally fell into disrepute.

At present, however, a clinical syndrome may be recognized in which the diagnosis of essential hæmaturia is not only justified but definitely indicated. If this entity is denied recognition, improper therapeutic efforts, leading perhaps to unwarranted surgical exploration and inaccurate prognosis, may result. The diagnosis of this disease still remains one of exclusion, permissible only after repeated general and urologic investigation, meticulously performed, reveals no demonstrable abnormality which could possibly be responsible for the bleeding. Clinically, there are usually no associated symptoms except persistent, intermittent hæmaturia. Occasionally, pain may be present and, if bleeding is severe and prolonged, secondary effects, in the form of anæmia, may develop. The similarity of the clinical syndrome among these patients, especially when present for years, suggests that under such circumstances a common etiologic and possibly pathologic basis exists.

In the ten kidneys studied, sufficient changes were noted to account for bleeding into the pelvis. The changes were confined largely to the papillæ and the associated tissues beneath the pelvic epithelium, and consisted of dilatation of the blood-vessels, interstitial hæmorrhage, mild chronic inflammatory

reactions, and fibrosis. The changes were not uniform and varied in degree, type and intensity. The most outstanding changes noted in any of the kidneys were in the tips of the papillæ in four of the cases, and consisted of marked dilatation of venules, with interstitial hæmorrhages. The complexity of these veins, their relative dilatation and thin walls, and their close relation to the epithelium of the pelvis in these cases serve as an excellent anatomic basis for bleeding into the pelvis. Significant changes in the glomeruli were not observed, and a pathologic diagnosis of nephritis could not be made in any instance.

In a series of five cases of essential hæmaturia studied by Wheeler in 1930, changes were observed which were almost identical with those noted in our series. Studies of these two groups of cases strongly suggest that the bleeding in the majority of cases of essential hæmaturia is due to vascular and chronic inflammatory disease in the pelvis, and particularly in the renal papillæ. The clinical history of the disease, the uniformity of symptoms, the frequent relief of bleeding following local applications to the renal pelvis, and a number of reports by other physicians of pathologic studies of removed kidneys in which the principal findings were limited to the pelvis and the papillæ, strongly point to such pathologic changes as those that underlie this clinical syndrome.

Discussion of the etiology of these changes is unsatisfactory, since we have insufficient knowledge of the character of the circulation in the pelvis and papillæ of the kidney and the various factors which may influence it. The part played by fibrotic changes in the pyramids, at the corticomedullary juncture, and beneath the pelvic epithelium in obstructing the free return flow of venous blood from these regions is questionable. The possible importance of this factor has been emphasized by Payne and McNider, and by Rathbun.

The part played by infection is also uncertain. Mild or marked chronic inflammatory changes may be present in the tissues mentioned. Whether they are independent of the fibrotic changes or directly responsible for them is a question which cannot be answered in every case. Clinical evidence would be in favor of infection as a significant feature, at least in the exacerbations of bleeding.

SUMMARY

One hundred cases are reviewed, in which the diagnosis of essential hæmaturia was made at The Mayo Clinic. The clinical features, possible etiologic factors, diagnostic criteria, therapeutic indications, and prognosis of these cases are considered. Careful histologic study of ten kidneys removed because of this condition is presented. Consideration of essential hæmaturia as an accurate urologic diagnosis with recognizable associated pathologic changes is considered.

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